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Rio Blanco Oil Shale Project

DETAILED DEVELOPMENT PLAN TRACT C-a

VOLUME 4

ENVIRONMENTAL PROTECTION and MONITORING

Gulf Oil Corporation . Standard Oil Company(Indiana)

March, 1976

U. S. DEPARTMENT OF INTERIOR
OIL SHALE
ENVIRONMENTAL ADVISORY PANEL
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RIO BLANCO OIL SHALE PROJECT

DETAILED DEVELOPMENT PLAN
TRACT C-a

VOLUME 4

SECTION 9 ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

SECTION 10 ENVIRONMENTAL ASSESSMENT

SECTION 11 ENVIRONMENTAL MONITORING

**Submitted To Area Oil Shale Supervisor,
Geological Survey, U.S. Department of
the Interior, Pursuant To Lease No. C-20046**

**Gulf Oil Corporation - Standard Oil Company (Indiana)
March, 1976**

DDP ABSTRACT

In 1969, the U.S. Department of the Interior initiated planning for a prototype oil shale leasing program that eventually resulted in Gulf Oil Corporation and Standard Oil Company (Indiana) acquiring an oil shale lease for Tract C-a in the Piceance Creek basin of northwest Colorado. Gulf and Standard submitted the high bonus bid for Tract C-a ($210,305,600) at a lease sale in Denver on January 8, 1974. Rio Blanco Oil Shale Project (RBOSP) an organization directed and staffed by representatives of Gulf and Standard, was formed later that year for the purpose of developing Tract C-a.

In the past two years, RBOSP has conducted extensive geotechnical and environmental data collection programs designed to establish baseline conditions on and around Tract C-a and to provide input to engineering studies leading to the selection of mining and processing plans for Tract C-a development. This 4-volume detailed development plan (DDP) describes the baseline conditions and RBOSP's proposed construction and operation of a commercial-scale oil shale complex and support facilities on and around Tract C-a. Three major requirements must be met before development operations on Tract C-a can begin:

- The Area Oil Shale Supervisor, U.S. Geological Survey, must approve the development plan.
- Key Federal and State actions must be fulfilled and permits issued.
- The proposed development described in this plan must be commercially feasible at the time investments are committed.

PROJECT DESCRIPTION

RBOSP's ultimate goal with respect to Tract C-a development is to engage in commercial production of shale oil and associated by-products at as high a production rate as is feasible, consistent with environmental, technical and economic constraints that now prevail or may exist in the future.

Development will consist of open pit mining, off-tract surface retorting, and off-tract disposal of processed shale and overburden, and will be undertaken in two operating phases, each preceded by three-year construction periods. Phase I operation will consist of two stages, wherein first one, then two retort modules will be operated. This modular approach will provide RBOSP the opportunity to gain operating experience, improve process efficiency and confirm capital and operating costs before a full-scale oil shale complex is built. Phase II will be the commercial-scale complex. Table 1 is a summary of information pertinent to RBOSP's proposed development of Tract C-a. Figure 1 depicts the location of proposed RBOSP facilities.

Phase I - Stage 1 operations will begin during 1979 with a small open pit mine and a single TOSCO II retort capable of processing 10,700 tons of oil shale per day to produce approximately 4,500 barrels of pipelineable shale oil daily. Phase I - Stage 1 will include a thermal cracking plant for lowering the viscosity and pourpoint of raw shale oil so that it can be transported by pipeline. A sulfur recovery unit will also be included.

TABLE 1

RIO BLANCO PROJECT SUMMARY

	PHASE I		PHASE II
	Stage I	Stage 2	
TIMING			
Construction	Apr. 1977-Aug. 1979	July 1980-Aug. 1982	Aug. 1982-Aug. 1985
Operation	Aug. 1979-Aug. 1982	Aug. 1982-Aug. 1985	Aug. 1985 and beyond
MINING			
Type	Open Pit	Open Pit	Open Pit
Ore Production	10,700 TPSD	21,400 TPSD	119,000 TPSD
Ore Haulage	Belt Conveyor	Belt Conveyor	Belt Conveyor
Overburden Haulage	Truck	Truck	Belt Conveyor
PROCESSING			
Retorting	TOSCO II	TOSCO II	Combination of TOSCO II & Gas Combustion/Paraho
Upgrading	Thermal Cracking	Thermal Cracking	Delayed Coking & Hydrotreating
Processed Shale Haulage	Truck	Truck	Belt Conveyor
PRODUCTS			
Pipelineable Shale Oil	4,500 BPSD	9,000 BPSD	-
Upgraded Shale Oil	-	-	55,800 BPSD
Sulfur	11 LTPSD	22 LTPSD	153 LTPSD
Ammonia (anhydrous)	-	-	232 TPSD
Coke	-	-	467 TPSD
Moisturized Processed Shale	11,000 TPSD	22,000 TPSD	118,500 TPSD
WATER DEMAND	1,390 AFY	2,370 AFY	10,000 AFY
POWER DEMAND	17.7 MW	28.8 MW	227 MW
PEAK EMPLOYMENT			
Construction	700	400	2,200
Operation	300	500	1,100

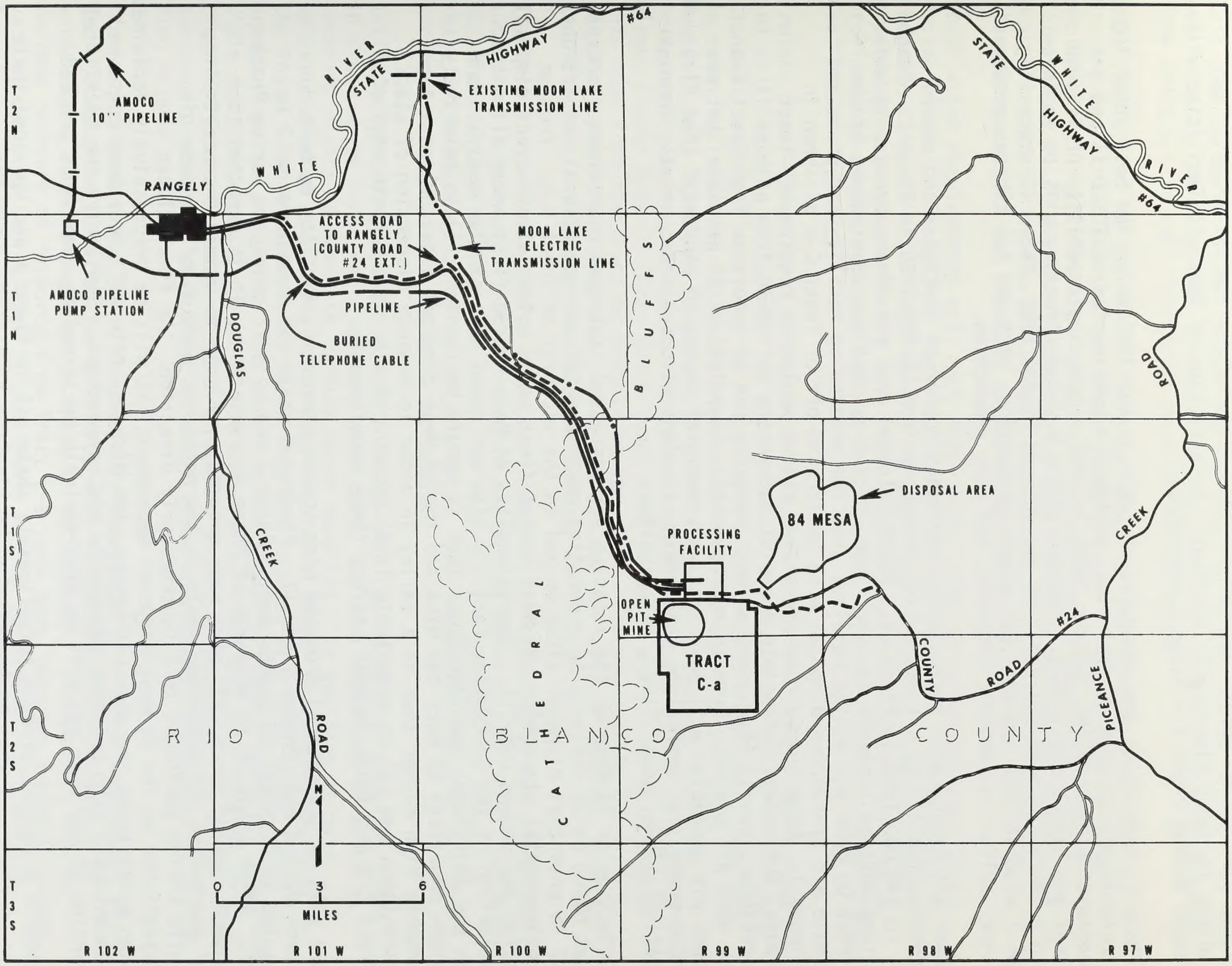


Figure 1

LOCATION OF PROPOSED RBOSP FACILITIES

Phase I - Stage 2 operations will begin three years later, during 1982, with the addition of a second TOSCO II retort, bringing total production to about 9,000 barrels per stream day (BPSD). Operation of the thermal cracking and sulfur recovery plants will continue. Construction of Phase II facilities will begin during Phase I - Stage 2 operations.

Phase II operations are scheduled to begin in mid-1985 using the best retorting technology available at that time, probably a combination of TOSCO II and gas combustion-type Paraho retorts, with a total processing capability of 119,000 tons per stream day (TPSD). Delayed coking and hydrotreating will be employed to produce upgraded shale oil at the rate of 55,800 BPSD. Phase II processing will also include hydrogen and oxygen production, high and low BTU gas production, sulfur and ammonia recovery, and coke production.

Open pit mining will begin in the northwest corner of Tract C-a and expand southeastwardly as ore production increases from 10,700 TPSD in Phase I - Stage 1 to 119,000 TPSD in Phase II. RBOSP selected open pit mining because it will allow maximum resource recovery from Tract C-a. Optimum development of the tract by open pit mining requires that the processing facility and processed shale and overburden disposal area be located off of Tract C-a as shown in Figure 1. Underground room-and-pillar mining would not require off-tract lands, but unless a feasible means of recovering oil shale from pillars is developed, nearly five times as much resource can be recovered from Tract C-a by open pit mining. From an environmental viewpoint, it is probable that one open pit operation will have less environmental impact in many ways than five room-and-pillar operations with their attendant disposal areas, roads, communications lines, power lines, and pipelines.

Selection of 84 Mesa as the location for processed shale and overburden disposal was based on an analysis incorporating environmental and operational comparisons of 16 potential disposal sites on and in the vicinity of Tract C-a. From an environmental standpoint, 84 Mesa ranked first among potential off-tract disposal sites and second overall. Operationally, 84 Mesa ranked first among all sites. Selection of the processing facility site was based on a similar analysis and on the additional considerations that it should be located: (1) in relatively close proximity to both the mine and the 84 Mesa disposal site; (2) on a topographic high rather than in a valley in order to enhance dispersion of stack emissions; and (3) on relatively level ground. A site at the north edge of Tract C-a was found to best satisfy these requirements.

Ore will be transported from the mine to the processing facility by belt conveyor during both Phases I and II. Processed shale and overburden will be hauled to disposal by trucks during Phase I and by belt conveyors during Phase II. After about 30 to 40 years of Phase II operations, it is expected that enough working space will have been created by mining to permit the backfilling of overburden and processed shale in the northwest portion of the open pit while mining continues in a southeasterly direction. As final slopes are established on the 84 Mesa disposal embankment, it will be progressively reclaimed. When backfilling the open pit begins, the disposal pile will have been contoured commensurate with existing topography and revegetated. Similarly, the backfilled portion of the open pit will be progressively reclaimed as operations proceed.

RBOSP's principal product (pipelineable shale oil in Phase I and upgraded shale oil in Phase II) will be transported by pipeline to Rangely, Colorado, thence through an existing AMOCO pipeline to other connecting carriers for ultimate delivery to refineries in the West or Midwest; a possible exception to this plan is during Phase I when shale oil may be trucked to an existing refinery near Fruita, Colorado. By-products (sulfur, ammonia and coke) will be trucked from Tract C-a to rail facilities near Rifle, Colorado.

RBOSP employment during Phase I will be about 700 for construction, 300 for Stage 1 operations and 500 for Stage 2 operations. Phase II construction employment will peak at about 2,200 while the Phase II operating force will total about 1,100 permanent employees. Overall RBOSP employment is expected to peak at 2,700 during the period from mid-1982 to mid-1985 when both Phase I - Stage 2 operations and Phase II construction are underway.

RBOSP water requirements will vary from about 1,400 acre-feet per year (AFY) during Phase I - Stage 1 to some 10,000 AFY during Phase II. Current data indicate that all water requirements through Phase II can be supplied from ground water sources on Tract C-a. Normal mine dewatering operations should provide most of the required amount, but some supplementary wells (all on Tract C-a) may be necessary.

Project power demand will be about 18 MW during Phase I - Stage 1 operations and will increase to some 227 MW during Phase II. Moon Lake Electric Association will supply electricity to Tract C-a via a 230-KV transmission line from an existing line near the White River some 20 miles north of the tract. Mountain Bell Telephone Company will provide communications via a buried telephone cable from Rangely. Vehicular access to Tract C-a will be via Rio Blanco County Road 24 (Ryan Gulch Road) from the east and via an extension of this road from the tract to Rangely on the west. The power tranmission line, shale oil pipeline, telephone cable, and access road will be located, wherever possible in a common corridor between Rangely and Tract C-a.

If Phase II operations prove to be environmentally, technically and economically successful, RBOSP may elect to increase production above 55,800 BPSD. Current RBOSP estimates indicate that Tract C-a reserves are adequate to support a shale oil production of up to 300,000 BPSD. Such expansion could be achieved, for example, in two-125,000 BPSD increments.

Anticipating this possibility, RBOSP is already taking initial planning steps in areas where long lead times are necessary, the most important of which is securing rights to adequate surface water supplies. In addition to more water, increased production would also require a larger processing facility -- the Phase I and II processing facilities are located at a site where there is enough room for expansion. The need for additional off-tract lands for processed shale and overburden disposal is not anticipated since the void created during the first 30 to 40 years of Phase II mining should be sufficient to allow subsequent mining to stay ahead of backfilling operations, regardless of production rates.

Expansion beyond Phase II is treated only conceptually in this development plan because detailed planning for such expansion (excepting the acquisition of water rights) cannot begin until Phase II is underway. Ultimately, however, maximum recovery of resource from Tract C-a (and thus, maximum resource conservation) can only be realized by completely mining the tract. Furthermore, leaving exposed mining faces at the south and east boundaries of Tract

C-a will permit future developers on adjacent leases to continue open pit mining where RBOSP operations end.

BASELINE ENVIRONMENTAL AND GEOTECHNICAL CONDITIONS

As noted earlier, RBOSP has initiated extensive geotechnical and environmental baseline data collection programs on and around Tract C-a. These programs are designed to obtain data needed for engineering studies and development plans as well as fulfilling specific lease requirements.

Geotechnical data collection is subdivided into geologic and hydrologic programs. The geologic program is designed to provide detailed topographic, structural, stratigraphic, and resource data. The hydrologic program will provide data for determining baseline hydrologic conditions, aquifer characteristics, and for predicting the quantity of water expected to be produced during open pit mining.

The baseline environmental program designed by RBOSP complies with lease stipulations and, in addition, reflects the following goals: (1) to identify any potential data gaps that might exist in the lease stipulations and develop programs to correct such oversights; and (2) to evaluate lease stipulations and, if appropriate, suggest amendments that would best serve the environmental spirit enunciated in the lease.

The baseline environmental program was approved by the Area Oil Shale Supervisor following review and recommendations by the Oil Shale Environmental Advisory Panel. The program includes data collection in the following disciplines: air quality, meteorology, terrestrial and aquatic ecology, soil characterization, archaeology, and paleontology. Data from all elements are combined to describe overall ecological interactions. Incorporated in the design of these programs is a flexibility allowing response to changes indicated by the constantly expanding data base, without altering original objectives. For example, the study area in some programs was expanded from the original design to ensure coverage of potential disposal and processing facility sites. In addition to characterizing the physical and biological components of the Tract C-a study area, both qualitatively and quantitatively, the baseline environmental program will yield data for designing a monitoring program to measure changes caused by development.

ENVIRONMENTAL PROTECTION

RBOSP has developed specific environmental protection procedures to ensure compliance with lease provisions and environmental stipulations, and with all applicable Federal, State and local environmental protection and pollution control regulations. These procedures, or mitigation plans, are designed specifically for RBOSP's intended development of Tract C-a and will be modified, if necessary, as changing conditions are noted. The protection procedures described in this development plan cover the following topics:

Health and Safety
Air Quality Control
Water Quality Control
Solid Waste Control
Noise Control
Aesthetics
Abandonment
Fish and Wildlife Management
Land Rehabilitation
Oil and Hazardous Materials Control
Fire Prevention and Control
Protection of Objects of Historic and Scientific Interest

RBOSP has conducted an environmental assessment of proposed Tract C-a development. This assessment was based on the fact that the protection plans listed above will be implemented and that they will be modified as conditions dictate. The results of this assessment are that Tract C-a development alone will have slight, if any, impact on the functioning of the overall Piceance Creek basin ecosystem.

Various environmental monitoring programs will be conducted to provide a record of changes from conditions existing prior to development as established by the baseline data collection program, and to serve as a continuous check on compliance with lease provisions and applicable Federal, State and local environmental protection and pollution control regulations. Programs have been designed to monitor air quality, meteorology, hydrology, terrestrial and aquatic ecology, and revegetated areas. Analysis of data collected during the baseline program provides the basis for selecting those parameters that will most effectively indicate detrimental effects and, thus, the necessity for taking corrective action such as altering one of the environmental protection plans.

The monitoring programs will be initiated six months before development begins on Tract C-a. Monitoring will continue until the Area Oil Shale Supervisor determines to his satisfaction that environmental conditions consistent with Federal and State statutes and regulations have been established.

SOCIO-ECONOMIC PLANNING

Gulf and Standard recognized the potential social and economic impacts of oil shale development when the Tract C-a lease was acquired in January 1974. The two companies pledged then to cooperate with, support and participate in regional planning with the communities affected and with local, county, state and Federal governmental agencies.

A socio-economic plan is not legally required by the Tract C-a lease, but RBOSP officials and the Area Oil Shale Supervisor feel that such a plan is desirable. The overall objectives of RBOSP's socio-economic planning activities are to reduce negative impacts and to avoid the mistakes and resulting problems encountered in other areas experiencing significant population increases caused by new industry. RBOSP's plan to achieve these goals is described in a socio-economic report submitted separately from the detailed development plan.

STATE AND FEDERAL ACTIONS NEEDED BEFORE RBOSP CAN PROCEED

A variety of state and Federal actions are necessary before RBOSP can implement development of Tract C-a as described in this document. Specific actions needed are as follow:

- Area Oil Shale Supervisor approval of the detailed development plan
- Bureau of Land Management issuance of right-of-way permits for
    - pipeline to Rangely
    - road to Rangely
    - power transmission line
    - telephone cable
- BLM approval of use of 84 Mesa for disposal area
- BLM approval of use of offsite lands for processing facility
- Townsite lands are made available to Rangely by the BLM
- State appropriation for and construction of access roads
- State legislation to enable a town to receive and administer townsite lands
- An acceptable land trade with State Division of Wildlife for surface lands on and around Tract C-a
- State reclassification of air quality designation for area on and around Tract C-a
- Issuance of all required State and Federal permits

DDP ORGANIZATION AND USE

RBOSP's DDP consists of 11 sections comprising four volumes, as depicted in the chart on page 9. Volume 1 includes sections entitled "Project Background" and "Executive Summary." If one is interested in an overview of the development plan, Volume 1 is recommended.

Volume 2 is the largest of the four volumes. It describes baseline geological, hydrological and environmental conditions on and around Tract C-a. Volume 3 describes engineering plans for developing Tract C-a and includes sections on mining, retort feed preparation, processing, processed shale and overburden disposal and support facilities. Volume 4 describes RBOSP's environmental protection plans and also includes sections concerning environmental assessment and monitoring. The Confidential Volume, which is not publicly available, contains proprietary information concerning oil shale properties and ore reserve and cost estimates.

Except for the DDP abstract, a 3-number page numbering system is used throughout the development plan. Any given page number is unique in that it is not repeated elsewhere in the DDP. Page numbers are keyed to chapters within sections; page 3-4-45, for example refers to the 45th page of Chapter 4, (Hydrology) of Section 3 (Baseline Conditions).

RIO BLANCO OIL SHALE PROJECT
DETAILED DEVELOPMENT PLAN ORGANIZATION

VOLUME 1

PROJECT BACKGROUND & EXECUTIVE SUMMARY

SECTION 1

PROJECT BACKGROUND

CHAPTER

1 INTRODUCTION
2 PROTOTYPE OIL SHALE LEASING PROGRAM
3 LEASE PROVISIONS
4 DETAILED DEVELOPMENT PLAN
5 PROJECT HISTORY

SECTION 2

EXECUTIVE SUMMARY

CHAPTER

1 PROJECT OVERVIEW
2 BASELINE CONDITIONS
3 PROJECT CONSTRUCTION ACTIVITIES
4 MINING
5 RETORT FEED PREPARATION
6 PROCESSING
7 PROCESSED SHALE & OVERBURDEN DISPOSAL
8 SUPPORT FACILITIES
9 ENVIRONMENTAL PROTECTION, HEALTH & SAFETY
10 ENVIRONMENTAL ASSESSMENT
11 ENVIRONMENTAL MONITORING

VOLUME 2

BASELINE CONDITIONS

SECTION 3

BASELINE CONDITIONS

CHAPTER

1 INTRODUCTION
2 GENERAL DESCRIPTION OF PROJECT AREA
3 GEOLOGY
4 HYDROLOGY
5 AIR QUALITY
6 METEOROLOGY
7 TERRESTRIAL ECOLOGY
8 AQUATIC ECOLOGY
9 SEISMICITY
10 ARCHAEOLOGY
11 PALEONTOLOGY
12 SOILS & OVERBURDEN
13 TRACE METALS
14 ECOLOGICAL INTERACTIONS

VOLUME 3

MINING, PROCESSING & SUPPORT FACILITIES

SECTION 4

MINING

CHAPTER

1 INTRODUCTION
2 GENERAL MINE DESCRIPTION & SCHEDULE
3 MINE DESIGN & OPERATION
4 MAJOR ALTERNATIVES & SELECTION RATIONALE
5 MINE DESIGN PARAMETERS

SECTION 5

RETORT FEED PREPARATION

CHAPTER

1 INTRODUCTION
2 PHASE I DESIGN & OPERATIONS
3 PHASE II DESIGN & OPERATIONS
4 ALTERNATIVES & SELECTION RATIONALE

SECTION 6

PROCESSING

CHAPTER

1 INTRODUCTION
2 PROCESSING FACILITY LOCATION
3 PHASE I PROCESSING OPERATIONS
4 PHASE II PROCESSING OPERATIONS
5 PLOT PLAN
6 PHASE II PROCESSING ALTERNATIVES
7 PHASE I PROCESSING ALTERNATIVES

SECTION 7

PROCESSED SHALE & OVERBURDEN DISPOSAL

CHAPTER

1 INTRODUCTION
2 SITE ALTERNATIVES & SELECTION RATIONALE
3 PHASE I DISPOSAL OPERATIONS
4 PHASE II DISPOSAL OPERATIONS

SECTION 8

SUPPORT FACILITIES

CHAPTER

1 INTRODUCTION
2 TRANSPORTATION
3 POWER SUPPLY & DISTRIBUTION
4 PRODUCT PIPELINE
5 WATER SUPPLY & DISTRIBUTION
6 COMMUNICATIONS
7 STORAGE OF FUEL & OTHER FLAMMABLE PRODUCTS
8 BUILDINGS

VOLUME 4

ENVIRONMENTAL PROTECTION & MONITORING

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH & SAFETY

CHAPTER

1 INTRODUCTION
2 HEALTH & SAFETY
3 FIRE PREVENTION & CONTROL
4 NOISE CONTROL
5 AIR QUALITY CONTROL
6 WATER QUALITY CONTROL
7 OIL & HAZARDOUS MATERIAL CONTROL
8 LAND REHABILITATION & EROSION CONTROL
9 SOLID WASTE CONTROL
10 AESTHETICS
11 FISH & WILDLIFE MANAGEMENT
12 PROTECTION OF OBJECTS OF HISTORIC & SCIENTIFIC INTEREST
13 ABANDONMENT

SECTION 10

ENVIRONMENTAL ASSESSMENT

CHAPTER

1 INTRODUCTION
2 AIR
3 HYDROLOGY
4 AQUATIC ECOLOGY
5 TERRESTRIAL ECOLOGY

SECTION 11

ENVIRONMENTAL MONITORING

CHAPTER

1 INTRODUCTION
2 AIR QUALITY
3 METEOROLOGY
4 TERRESTRIAL ECOLOGY
5 AQUATIC ECOLOGY
6 HYDROLOGY
7 REVEGETATION

CONFIDENTIAL VOLUME

GEOLOGIC INFORMATION
ROCK MECHANICS DATA
RECOVERABLE OIL SHALE RESERVES
COST ESTIMATE

CONTENTS

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 1 INTRODUCTION

CHAPTER 2 HEALTH AND SAFETY

2.1 Applicable Regulations 9-2-1

2.2 Personnnel Responsibilities. 9-2-2

2.3 Safety and Accident Prevention Program 9-2-3

2.4 Reports and Logs 9-2-5

2.5 Special Concerns 9-2-5
A. Airborne Contaminants 9-2-5
B. Noise Control 9-2-7
C. Explosives. 9-2-7
D. Electrical Facilities 9-2-11
E. Machinery and Equipment 9-2-12
F. First Aid and Medical Facilities. 9-2-12
G. Health and Sanitation 9-2-13
H. Signs and Posters 9-2-14
I. Personal Protective and Life-Saving Equipment 9-2-14
J. Protection of the Public. 9-2-15

CHAPTER 3 FIRE PREVENTION AND CONTROL

3.1 Applicable Regulations 9-3-1

3.2 Construction 9-3-2
A. Tools and Equipment .9-3-2
B. Special Precautions .9-3-2
C. Open Burning. 9-3-4

3.3 Processing Facility. 9-3-5
A. Plant Design and Layout 9-3-5
B. Plant Inspections 9-3-8
C. Fire Protection Equipment 9-3-9
D. Fire Protection Water System. 9-3-9
E. Major Equipment 9-3-10
F. Communication System. 9-3-11

3.4 Mobile Equipment 9-3-12

3.5 Stockpiles 9-3-13

3.6 Crushers, Conveyors and Baghouses. 9-3-13

3.7 Offices, Warehouses and Shops. 9-3-13

3.8 Fuel Storage and Dispensing. 9-3-14

3.9 Welding and Cutting Operations 9-3-14

3.10 Management and Training. 9-3-15
A. Training. 9-3-15
B. Emergency Procedures. .9-3-16

CHAPTER 4 NOISE CONTROL

4.1 Regulations. 9-4-1

4.2 Noise Levels 9-4-1

4.3 Control Methods. 9-4-2

CHAPTER 5 AIR QUALITY CONTROL

5.1 Construction 9-5-1
A. Roads 9-5-1
B. Mine Site 9-5-2
C. Processing Facility 9-5-2
D. Processed Shale and Overburden Disposal Area. 9-5-3
E. Support Facilities. 9-5-3
F. Burning Control 9-5-3
G. Construction Vehicles and Equipment 9-5-3

5.2 Mining 9-5-4
A. Phase I 9-5-4
B. Phase II. 9-5-5

5.3 Crushing, Conveying and Stockpiling. 9-5-5
A. Phase I 9-5-6
B. Phase II. 9-5-9

5.4 Processing 9-5-15
A. Phase I 9-5-15
B. Phase II. 9-5-18

5.5 Processed Shale and Overburden Disposal. 9-5-22
A. Phase I 9-5-22
B. Phase II. 9-5-25

5.6 Support Facilities 9-5-26

5.7 Modeling 9-5-27
A. Dispersion Modeling 9-5-27
B. Fumigation Modeling 9-5-85
C. Salt Drift From Cooling Towers. 9-5-93

5.8 Applicable Regulations 9-5-100
  A. Tract C-a Oil Shale Lease 9-5-100
  B. National Environmental Policy Act of 1969 and the Environmental Protection Agency 9-5-100
  C. The Occupational Safety and Health Act of 1970. 9-5-100
  D. Mining Enforcement and Safety Administration (MESA) . .9-5-100
  E. State of Colorado Air Pollution Control Act of 1970 9-5-101
  F. Colorado Mining Laws with Safety and Health Regulations. 9-5-101
  G. Colorado Departent of Labor and Colorado Occupational Safety and Health (COSH) 9-5-101

5.9 Definitions. 9-5-102

Literature Cited. 9-5-107

CHAPTER 6 WATER QUALITY CONTROL

6.1 Zero Discharge Water Handling. 9-6-4

6.2 Water Control on Tract C-a 9-6-4
  A. Mine. 9-6-7
  B. Processing Facility .9-6-8
  C. Processed Shale and Overburden Disposal Pile. 9-6-9
  D. General Storm Drainage Control. 9-6-10
  E. Summary 9-6-11

CHAPTER 7 OIL AND HAZARDOUS MATERIAL CONTROL

7.1 Applicable Regulations .9-7-1

7.2 Storage and Handling 9-7-2
  A. Storage 9-7-2
  B. Handling of Pesticides. 9-7-2

7.3 Spill Contingency. 9-7-3
  A. Nontransportation - Related Facilities. 9-7-3
  B. Transportation - Related Facilities 9-7-7

CHAPTER 8 LAND REHABILITATION AND EROSION CONTROL

8.1 Areas Affected 9-8-1

8.2 Site Preparation 9-8-1
  A. Soil Conservation 9-8-3
  B. Artificial Soil Profile 9-8-3

8.3 Erosion Control

  A. Material Size and Classification. 9-8-6
  B. Slope and Surface Treatment 9-8-7
  C. Drainage. 9-8-7
  D. Temporary Measures. .9-8-8

8.4 Revegetation 9-8-10
    A. Revegetation Technology 9-8-11
    B. Experiments 9-8-26

CHAPTER 9 SOLID WASTE CONTROL

9.1 Nonprocess Wastes. 9-9-1
    A. Composition and Quantity. 9-9-1
    B. Collection and Transport. 9-9-2
    C. Disposal. 9-9-2

9.2 Process Wastes 9-9-3
    A. Phase I 9-9-3
    B. Phase II. 9-9-3

CHAPTER 10 AESTHETICS

10.1 Location 9-10-1

10.2 Materials and Color. 9-10-1

10.3 Shape. 9-10-3

10.4 Vegetation 9-10-3

10.5 Clearing 9-10-7

10.6 Signs. 9-10-7

CHAPTER 11 FISH AND WILDLIFE MANAGEMENT PLAN

11.1 Purposes and Objectives. 9-11-5

11.2 Physical Setting 9-11-7

11.3 Wildlife Inventory and Baseline Result 9-11-9
    A. Terrestrial 9-11-9
    B. Aquatic 9-11-17

11.4 Human Utilization of Wildlife Resources. 9-11-21
    A. Terrestrial 9-11-21
    B. Aquatic 9-11-23

11.5 Development-Associated Impacts 9-11-24
    A. Terrestrial 9-11-24
    B. Aquatic 9-11-29

11.6 Specific Impact-Related Mitigation 9-11-30
    A. Terrestrial 9-11-30
    B. Aquatic 9-11-33

11.7 Wildlife Habitat Enhancement and Restoration. 9-11-33
A. Terrestrial. 9-11-33
B. Aquatic. 9-11-44

11.8 Human Disturbance Control 9-11-44
A. Vehicle-Animal Collisons 9-11-45
B. Legal Wildlife Harvest 9-11-46
C. Illegal Wildlife Harvest 9-11-46
D. Off-Road Vehicle Use 9-11-47
E. Harassment by Humans and Companion Animals 9-11-47

11.9 Monitoring Program. 9-11-48
A. Terrestrial. 9-11-48
B. Aquatic. 9-11-56

11.10 Quality Assurance and Administration. 9-11-56
A. Pre-Implementation Planning. 9-11-57
B. Implementation 9-11-57
11.11 Periodic Review 9-11-58

Literature Cited 9-11-59

CHAPTER 12 PROTECTION OF OBJECTS OF SCIENTIFIC AND HISTORIC INTEREST

12.1 Site Preservation and Salvage 9-12-1
A. Archaeologic 9-12-1
B. Paleontologic. 9-12-2
C. Historic 9-12-2

12.2 Equipment Operator Training 9-12-2

12.3 Notice of Finds 9-12-2

CHAPTER 13 ABANDONMENT

13.1 Mine 9-13-2
A. Phase I. 9-13-2
B. Phase II 9-13-3
C. Ultimate Open Pit. 9-13-5
D. Other Long Range Considerations. 9-13-5

13.2 Processing Facility 9-13-6

13.3 Processed Shale and Overburden Disposal Site. 9-13-7

13.4 Support Facilities. 9-13-7

SECTION 10

ENVIRONMENTAL ASSESSMENT

CHAPTER 1 INTRODUCTION 10-1-1

CHAPTER 2 AIR 10-2-1

CHAPTER 3 HYDROLOGY

3.1 Mining 10-3-1
- A. Precipitation 10-3-1
- B. Springs and Seeps .10-3-1
- C. Streams 10-3-1
- D. Alluvial Aquifers .10-3-4
- E. Deep Aquifers 10-3-4

CHAPTER 4 AQUATIC ECOLOGY

4.1 Mining 10-4-1
- A. Phase I 10-4-1
- B. Transition Phase. .10-4-4
- C. Phase II. 10-4-5

4.2 Retort Feed Preparation. 10-4-7
- A. Phase I 10-4-7
- B. Transition Phase. .10-4-7
- C. Phase II. 10-4-7

4.3 Processing 10-4-8
- A. Phase I 10-4-8
- B. Transition Phase. .10-4-8

4.4 Processed Shale and Overburden Disposal. 10-4-9
- A. Phase I 10-4-9
- B. Transition Phase. .10-4-10
- C. Phase II. 10-4-11

4.5 Ancillary Facilities .10-4-12
- A. Phase I 10-4-12
- B. Transition Phase. .10-4-13
- C. Phase II. 10-4-13

CHAPTER 5 TERRESTRIAL ECOLOGY

5.1 Mining 10-5-4
- A. Phase I 10-5-4
- B. Transition Phase. .10-5-14
- C. Phase II. 10-5-14

5.2 Retort Feed Preparation. 10-5-15
- A. Phase I 10-5-15

B. Transition Phase. 10-5-15
C. Phase II. 10-5-16

5.3 Processing 10-5-16
A. Phase I 10-5-16
B. Transition Phase. 10-5-19
C. Phase II. 10-5-20

5.4 Processed Shale and Overburden Disposal. 10-5-28
A. Phase I 10-5-28
B. Transition Phase. 10-5-31
C. Phase II. 10-5-32

5.5 Support Facilities 10-5-33
A. Phase I 10-5-33
B. Transition Phase. 10-5-36
C. Phase II - (Support Facilities) 10-5-36

5.6 Summary of Impact Category 10-5-38
A. Area Disturbance. 10-5-38
B. Processing Plant Emissions. 10-5-40
C. Mine Dewatering 10-5-41
D. Dust. 10-5-41
E. Noise 10-5-42
F. Human Presence. 10-5-42

5.7 Overview 10-5-43

Literature Cited. 10-5-47

SECTION 11

ENVIRONMENTAL MONITORING

CHAPTER 1 INTRODUCTION 11-1-1

CHAPTER 2 AIR QUALITY

2.1 Ambient Monitoring 11-2-1
A. Parameters. 11-2-2
B. Sample Sites. 11-2-2
C. Measurement Frequency 11-2-5

2.2 Source Emission Monitoring 11-2-5

CHAPTER 3 METEOROLOGY

3.1 Meteorological Monitoring. 11-3-1
A. Parameters. 11-3-1
B. Sample Sites Identification 11-3-1
C. Frequency 11-3-4

CHAPTER 4 TERRESTRIAL ECOLOGY

4.1 Introduction 11-4-1

4.2 Biological Parameters. 11-4-8
 A. Vegetation. 11-4-8
 B. Invertebrates 11-4-18
 C. Vertebrates 11-4-26

4.3 Non-Biological Parameters. 11-4-31
 A. Soils 11-4-32
 B. Meteorology 11-4-33
 C. Air Quality 11-4-33
 D. Chemical and Trace Element Analysis 11-4-33

4.4 Monitoring Analysis. 11-4-39
 A. Study Site Design 11-4-39
 B. Statistical Design. .11-4-40
 C. Parameter Interaction 11-4-42

Literature Cited. 11-4-44

CHAPTER 5 AQUATIC ECOLOGY

5.1 Aquatic Communities. 11-5-1

5.2 Objectives and Methods 11-5-3
 A. Physical Measurements 11-5-3
 B. Chemical Measurements 11-5-3
 C. Sediment Studies. 11-5-4
 D. Periphyton. 11-5-4
 E. Benthos 11-5-5
 F. Fish. 11-5-5

5.3 Sampling Location. 11-5-7

5.4 Sampling Frequency 11-5-8

Literature. 11-5-8

CHAPTER 6 HYDROLOGY

6.1 Surface Water Monitoring .11-6-1

6.2 Ground Water Monitoring. .11-6-3

CHAPTER 7 REVEGETATION

7.1 Criteria for Success 11-7-1

7.2 Monitoring Program 11-7-2
 A. Objectives. 11-7-2
 B. Methods 11-7-2

CHAPTER 1

INTRODUCTION

SECTION 9

ENVIRONMENTIAL PROTECTION, HEALTH AND SAFETY

CHAPTER 1
INTRODUCTION

Tract C-a lease stipulations require compliance with all applicable Federal, State and local statutes, regulations and standards relating to water pollution control, water quality, air pollution control, air quality, noise control and land rehabilitation. Further requirements are to avoid, minimize and where practicable, repair damage to the environment.

Rio Blanco Oil Shale Project is approaching the development of Tract C-a with a sincere desire to make its activities as free from environmental damage as is practicable. Toward this end, environmental interfaces have been included in all engineering work. This has permitted the development of designs and selection of equipment, alternatives and techniques that will mitigate or eliminate environmental damage.

The health and safety and environmental protection plans presented in this section have a threefold function:

- To set forth the pollution control devices and techniques planned for the project.
- To serve as guidelines for detailed design and equipment selection.
- To serve as guidelines for construction and operation of the various facilities in a manner to mitigate environmental damage as much as practicable.

The concept of development in phases will permit the evaluation of many of the environmental quality control techniques and equipment on a full-scale basis, with time to refine these plans prior to committing vast amounts of resources for the equipment required to implement Phase II. Planning has been concentrated on Phase I, but the concepts developed are directly applicable to the larger facilities required in Phase II. In instances where Phase II will introduce new problems to the environment, those problems are considered separately.

To cause the least possible impact on water quality, a no-discharge concept will be employed throughout the entire project. In no instance will contaminated water be discharged to the surface or ground water courses. Natural drainages will be diverted around operating areas to avoid contamination.

Rehabilitation, including revegetation, will be a continuing program, commencing in the early years with road and power line corridors. As disposal sites are brought to final configuration, revegetation will progress as closely behind the operation as is practicable.

The environmental control plans, equipment and techniques presented throughout the DDP and in this section, in particular, are based on current knowledge and technology in the field. Actual construction and operation of this project will provide some additional information on materials and processes which will permit changes and improvements to be made in the environmental control activities. Rio Blanco intends to take every opportunity to increase its ability to eliminate, minimize or mitigate any environmental degradation that may result from the oil shale development.

CHAPTER 2

HEALTH AND SAFETY

CHAPTER 2
HEALTH AND SAFETY

The RBOSP management intends to have this project designed, constructed and operated in a manner to produce a workplace that is as free as possible of hazards to either workers or the public. To this end, the project management and staff will be fully involved in the project safety effort.

2.1 APPLICABLE REGULATIONS

Pertinent Federal and State of Colorado health and safety standards and regulations have been reviewed, and the project planning has been and will continue to be directed to ensure design compliance. The principal regulations are:

- Code of Federal Regulations (CFR)
  Title 30, Part 55 - "Health and Safety Standards for Metal and Nonmetallic Open Pit Mines".
  Title 30, Part 56 - "Health and Safety Standards for Sand, Gravel and Crushed Stone Operations".
  Title 29, Part 1926 - "Occupational Safety and Health Regulations for Construction".
  Title 29, Part 1910 - "Occupational Safety and Health Standards".
  Title 26, Part 18 - "Commerce in Explosives".
- Colorado Mining Laws with Safety and Health Rules and Regulations, Bulletin 20, January 1, 1971.
- State of Colorado, Occupational Safety and Health Administration, Safety and Health Construction Standards.
- Uniform Building Code.
- National Electrical Code.
- National Electrical Safety Code.
- Various industry standards, such as those of the American Society for Testing and Materials, American Concrete Institute, American

Petroleum Institute, American Society of Mechanical Engineers and American National Standards Institute, as appropriate.

At the completion of final design and prior to the start of construction, a detailed Health and Safety program for the construction phase will be developed to include the necessary rules and codes to ensure that the facility will be built safely and in full compliance with all applicable regulations. Prior to the start of mining and processing facility operation a detailed Health and Safety program will be developed in a similar manner to cover all operations.

2.2 PERSONNEL RESPONSIBILITIES

The project manager during construction, and one of the top Rio Blanco management personnel during operation, will have full responsibility for executing and implementing a program of employee protection and accident prevention. He may delegate authority to expedite and facilitate any application of the program.

A safety engineer, responsible to the project manager (construction phase) or top Rio Blanco manager (operation phase) will be employed on the project. He will be charged with inspections and investigation of work methods for safe performance, orientation of new employees in safety practices, organization of safety meetings and supervision of first aid treatment and facilities. He will also be responsible for compiling all necessary records, logs and reports pertaining to safety required by the project and by Federal and State governmental agencies. He will investigate and report all accidents involving personnel or equipment and all damage to property caused by fire, flood or other occurrence.

Safety and other supervisory personnel will orient new employees and be responsible for the work methods and safety procedures followed on work assignments performed in their respective areas of responsibility. With the assistance of safety personnel, they will plan for and conduct periodic safety training meetings. They will comply with safety regulatory requirements generally applicable to the work and follow all directives relating to safety instituted by Rio Blanco management and safety engineer consistent with company policy and appropriate regulatory codes.

Subcontractors will be required to comply with the project safety program, standards, procedures, stipulations and regulations applicable to their work.

All employees must learn and comply with all safety rules and regulations applicable to their work and to the general safety of other workers on the project. Management will be responsible for making the project a safe place to work; however, each employee will be responsible for supporting management in providing a safe place to work, protecting himself and his fellow workers against injuries and reporting all safety hazards at once to project supervisors.

2.3 SAFETY AND ACCIDENT PREVENTION PROGRAM

A management safety committee will be formed with at least one member from each major department. The committee will meet monthly to:

- Promulgate and review safety procedures and policies.
- Discuss major accidents occurring prior to meetings, pointing out the causes and how the accidents could have been avoided.
- Discuss safety hazards and suggest methods to control or eliminate them.
- Develop continuing safety programs with emphasis on problem areas.
- Review progress of work on any necessary safety improvements.

Results of these meetings will be appropriately communicated to all employees through regular supervisory channels.

The safety engineer or other delegated person will make routine inspections of work areas. He will immediately bring any inadequate or deficient measure or unsafe work practice to the attention of a supervisor for correction. The safety engineer will inform the appropriate manager of all deficiencies that cannot be corrected immediately and/or that may result in damage to facilities or equipment or creates hazardous public exposure. All flammable-materials and explosives storage areas, shops, warehouses and other buildings will be inspected at regular intervals.

Appropriate mechanical safety inspections will be part of the equipment preventive maintenance program and as such will be the responsibility of both field and shop mechanical department supervisors and operating department supervisors. Records and reports will be an important part of the preventive maintenance program. Periodic spot check inspections may be made as required.

Management will be responsible for instructing each employee to recognize and avoid unsafe and hazardous conditions connected with his particular job and to be aware of and understand those safety regulations applicable to his working environment. As a minimum, the project's safety and health training program will include:

- Initial indoctrination by the safety supervisor or other representative of management. This indoctrination will cover general information about the safety program and the safety policies and regulations, as well as details relating to specific safety rules.
- Prework briefing and demonstration by individual supervisors. This phase will familiarize each employee with company approved, safe operating and working procedures and with existing or potential job hazards with regard to the specific tasks to be performed by the employee.
- Periodic safety training meetings. These meetings, which will be held by supervisors, will emphasize the safety rules, penalties for violating rules and standard codes, the causes of accidents in a particular trade and ways of preventing accidents. A record of these meetings, including major topics discussed and names of employees in attendance, will be maintained.
- Follow-up field training and supervision to ensure that safety rules and regulations are fully understood and are being complied with. On-the-job safety training is recognized as one of the most effective ways of educating workers.

2.4 REPORTS AND LOGS

The management and/or the safety engineer will be responsible for establishing and complying with record keeping and reporting requirements. Records and reports will include:

- Personal injuries and treatments received.
- Accident investigations.
- Reports to compensation carrier.
- Requirements of State and Federal agencies.
- Disabling (lost-time) accidents/injuries.
- Property damage.
- Testing logs, as required for dust, gas or explosive work.

2.5 SPECIAL CONCERNS

In addition to the information contained in this chapter, other portions of this section also concern health and safety, either directly, as in the case of Chapter 3, "Fire Prevention and Control," or indirectly, in other chapters. Sections 4, 5, 6, 7 and 8 also contain information relative to safety design features.

A. Airborne Contaminants - Wherever employees are exposed to concentrations of dust or fumes that are potentially harmful, a monitoring program will determine the levels of exposure and concentrations of the contaminants. Exposure can be alleviated by the proper use of personal protective equipment. Controlled-atmosphere control stations will be provided for operators where required.

Harmful and/or hazardous concentrations of fumes and harmful concentrations of dust are shown in Tables 9-2-1 and 9-2-2, respectively.

Gulf Oil Corporation and Standard Oil Company (Indiana) will conduct special investigations to determine the toxicity of oil shale dust and hydrocarbon fractions. The results of these investigations will be incorporated in the

Table 9-2-1

HARMFUL CONCENTRATION OF AIRBORNE CONTAMINANTS*

Chemical Compound or Product	Concentration (ppm)
Ammonia	50
Benzene	25
Carbon dioxide	5000
Carbon monoxide	50 (.005% by volume)
Chlorine	1
Gasoline	500
Hydrogen cyanide	10
Hydrogen sulfide	10
Methane	500 (.05% by volume)
Naphtha (petroleum)	100
Nitrogen oxides	25

*Colorado Mining Laws, Rules and Regulations, Bulletin 20, January 1, 1971, Part 71.2

Table 9-2-2

HARMFUL CONCENTRATIONS OF DUST*

Type of Dust	Million Particles Per Cubic Foot
Without free silica	50
With free silica	$250 \div (\% \ SiO_2 + 5)$

*Colorado Mining Laws, Rules and Regulations, Bulletin 20, January 1, 1971, Part 49.3

final health and safety plan, where appropriate, to protect the health of the workers and the public.

B. Noise Control - Federal regulations stipulate that no employee shall be exposed to noise levels in excess of those listed in Table 9-2-3.

Table 9-2-3

MAXIMUM NOISE EXPOSURE*

Duration (hr/day)	Sound Level (dbA, slow response)
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

Note: No exposure shall exceed 115 dbA. Impact noises shall not exceed 140 db, peak sound pressure level.

*30 CFR 57.5-50

Periodically, noise levels will be monitored for personnel health reasons using a sound meter meeting specifications for type 2 meters contained in American National Standards Institute Standard S1.41971.

When an employee's daily exposure is composed of two or more periods at different levels, the combined effect is the one considered. If exposure exceeds levels listed, engineering controls or personal protection equipment will be used to protect the worker.

C. Explosives - The Alcohol, Tobacco and Firearms Division of the U.S. Treasury Department has jurisdiction to enforce Federal regulations pertaining to commerce in explosives, which also include the storage and handling of explosives. Generally, State and Federal mining laws regulate the storage and handling of explosives as well as their use. However, these regulations are compatible with and do not supersede the Treasury Department regulations.

The storage and handling of explosives will be effectively regulated by the Colorado Bureau of Mines and the Mining Enforcement and Safety Administration. However, it is necessary to comply with the laws and regulations as enforced by the Treasury Department and defined in 26 CFR, Part 181. Salient features of these regulations are discussed below.

1. Definition of Explosives - Each year the Treasury Department publishes a list of recognized explosives that are regulated by law. Unmixed ammonium nitrate is not classified as an explosive. However, the mixed form of ANFO (ammonium nitrate-fuel oil), which is sensitive to a number 6 blasting cap, is classified as a blasting agent.

2. Classes of Explosives - Explosives are classified as: 1) high explosives; 2) low explosives; or 3) blasting agents. High explosives (dynamite, for example) can be detonated by a blasting cap when unconfined. Low explosives (black powder, for example) can be caused to deflagrate when confined. Blasting agents include less sensitive explosives, such as ANFO.

3. Storage Facilities for Explosives - There are five types of storage facilities for explosives:

Type 1 - permanent storage for high explosives
Type 2 - portable indoor/outdoor storage facilities for high explosives
Type 3 - portable outdoor facilities for temporary storage of high explosives
Type 4 - facilities for storage of low explosives or blasting agents
Type 5 - facilities for storage of blasting agents

Strict construction codes and limitations apply to each of the five types of storage facilities for explosives. These codes and limitations are detailed in 26 CFR, Part 181, Subpart J. All storage facilities for the project will meet or exceed these codes.

Unmixed ammonium nitrate may be stored in a suitable isolated wooden structure that will not create a fire hazard to other buildings in the area. The building interior will be well ventilated and protected from outside elements. Fuel oil will be stored in a separate, isolated outside tank.

ANFO in bags or cartridges will be stacked to allow free access by authorized persons and permit circulation of air. ANFO stored with other explosives is considered as equal weight with other explosives and will be separated from them by at least 24 inches in a manner to prevent fuel oil contamination.

The American Table of Distances, published by the Institute of Makers of Explosives, specifies the distances at which explosives can be safely stored from other structures (public highways, buildings or railways). Also, the tables specify minimum separation distances for blasting agents and high explosives. The amount of explosive to be stored and the design of the storage facility are functions that define the minimum separation distance between multiple storage bunkers, or between storage bunkers and inhabited buildings. The tables will be used in the design of storage and handling facilities for explosives and blasting agents.

4. Transport of Explosives - The guidelines listed below will be followed in transporting explosives and considered, along with pertinent regulations and specifics of the site, in developing detailed safety plans for operations.

- Vehicles containing explosives or detonators will be posted with proper warning signs.
- When vehicles containing explosives or detonators are parked, the brakes will be set, the motive power shut off and the vehicle blocked securely to prevent it from rolling.
- Vehicles containing explosives or detonators will not be taken to a repair garage or shop for any purpose.
- Vehicles used to transport explosives, other than blasting agents, will have substantially constructed bodies and no sparking metal exposed in the cargo space, and they will be equipped with suitable sides and tailgates.

- Explosives or detonators will be transported at times and over routes that expose a minimum number of persons.
- Other materials or supplies will not be placed on or in the cargo space of a conveyance containing explosives, detonating cord or detonators, except for safety fuse and except for properly secured, nonsparking equipment used expressly in the handling of such explosives, detonating cord or detonators.
- Only the necessary attendants will be permitted to ride on or in vehicles containing explosives or detonators.
- Vehicles containing detonators or explosives, other than blasting agents, will not be left unattended, except in blasting areas where loading or charging is in progress.

5. Use of Explosives - People using or handling explosives or detonators will be experienced personnel who understand the hazards involved; trainees will do such work only under supervision of and in the immediate presence of experienced personnel. All blasting operations will be under the direct control of the appropriate supervisor.

Holes to be blasted will be charged as near to blasting time as practical, and such holes will be blasted as soon as possible after charging has been completed. Unused explosives and detonators will be moved to a safe location as soon as charging operations have been completed. Areas in which charged holes are awaiting firing will be guarded, to prevent unauthorized entry. A warning alarm will be sounded to alert personnel in the area before blasting. Faces and muckpiles will be examined for undetonated explosives after each blast, and any undetonated explosives found will be disposed of safely.

Holes will not be drilled where there is danger of intersecting a charged or misfired hole. Workers will not be permitted to return to a misfired hole until at least 15 minutes have elapsed (for electric caps). If safety fuse has been used, 30 minutes must elapse before workers may return.

Smoking will not be permitted within 25 feet of any explosives or detonators. Other detailed rules will be promulgated as required to ensure the safe storage, handling and use of explosives at this project.

D. Electrical Facilities

1. Cables and Power Lines - Open conductors will not be used in hazardous locations (due to gassy or dusty atmosphere containing corrosive fumes) or in explosive magazines, changerooms, compressor rooms or battery-charging stations. Such wiring will be in conduit or approved cable type. Electric wiring in any magazine will be in conduit, protected by fuses, with no line of wiring within 5 feet of explosives stored therein. Potential on bare signal wires accessible to contact will not exceed 40 volts.

Power lines will be protected against voltage surges, short circuits and excessive loads, and circuit breakers and/or fuses will be provided. In addition, they will be separated or insulated from water, air and telephone lines. High-potential utility-pole guy wires will meet National Electric Safety Code requirements for grounding and insulators.

Power cables over 650 volts will be of a type approved for the service intended and will be installed according to the National Electrical Code and/or the National Electrical Safety Code. Trailing electric power cable will be connected to mobile equipment so as not to cause danger to the joints or terminal screws or fittings; energized cable will be handled only with insulated tongs or hooks.

2. Grounding - Metallic frames, fences, buildings, shielding and conduit, as well as motor casings, transformers, switch gear and all other electrical equipment that may be energized through insulation failure or contact with other energized parts, will be grounded. Continuity and resistance of ground circuits will be tested following installation. Ground wire will be attached to ground before the other end is attached to equipment. Electric blasting circuits from firing switch to blast area will not be grounded. Lightning arrestor grounds will be connected to earth at least 10 feet from mine return circuit.

3. Lightning Protection - Power lines, telephone lines and electrical equipment will be protected against lightning with arrestors.

4. Electrical Equipment - Hand-held or portable electrical equipment will not be operated above 500 volts, with a maximum voltage of 250 volts between each conductor. Equipment will not be operated closer than 10 feet to high-voltage power lines, unless such lines are de-energized or other precautionary measures are taken. Electrical equipment will be installed so as to be readily and safely accessible for maintenance. Where access or travel around stationary equipment is necessary, a minimum clearance of 3 feet will be provided.

Circuit breakers and/or fuses will be installed on all electrical equipment, including trail cables, to protect against overloads, short circuits, and voltage surges. Electrical equipment and circuits will be provided with enclosed safety switches of approved design, construction and installation. Disconnecting safety switches will be installed on all main power circuits on which separate circuits have separate switches. All switches, circuit breakers, starting boxes, power controls and other electrical equipment will be of adequate capacity and safe design, and will be mounted on insulating material.

E. Machinery and Equipment - All machinery and equipment will be designed, installed and operated in accordance with all appropriate regulations and safe practice guides to provide a safe working environment. All necessary safety devices and equipment will be provided to guard workers against injury.

F. First Aid and Medical Facilities - Project management will provide for adequate facilities and qualified personnel to ensure prompt and efficient first aid and medical care of injured employees. Personnel qualifications, facilities, services and supplies will conform to the good practice standards of the American Medical Association.

First aid stations will be established to comply with the requirements of the project. The facilities provided will be governed by the number of personnel employed on the project and in consideration of other medical care and facilities readily accessible and available to the work. Adequate identification and directional markers will be provided to denote the location of all project first aid stations.

A standby automotive unit will be provided for emergency transportation. This unit will be properly equipped to accommodate a stretcher and allow for prompt, comfortable transportation of personnel to medical or hospital facilities. When not available on the project, the project management will, in advance, make necessary arrangements for standby emergency transportation of injured employees. Medical and hospital arrangements will be made with nearby community facilities. All emergency telephone numbers will be posted conspicuously at appropriate locations.

In the absence of qualified doctors, nurses or first aid attendants, selected supervisory personnel will hold current American Red Cross or U.S. Bureau of Mines first aid certificates. Management will encourage all supervisors to become qualified for first aid certificates. At least one person with a valid certificate in first aid will be on duty at all times.

First aid kits will conform to Bureau of Mines standards and will consist of a weatherproof container with individually sealed packages for each type of item. First aid kits will be fully equipped before being sent out on each job and checked weekly to ensure that expended items have been replaced.

Standard Stokes type or equivalent stretchers and blankets will be strategically located in the work areas. They will be wrapped in visqueen or other waterproof material and stored in plainly marked and sealed waterproof containers.

G. Health and Sanitation - Drinking water will be secured from sources approved by Federal, State or local health authorities. It will be dispensed by means that will prevent contamination between source and consumer. The use of common drinking vessels will be prohibited. Where single-service cups are used, both a sanitary container for unused cups and a waste receptacle for disposing of used cups will be provided. Any container used to distribute drinking water will be clearly marked as to the nature of its contents and will not be used for any other purpose. Outlets for nonpotable water, such as water for industrial or fire fighting purposes will be conspicuously posted, "Danger, Water Unfit for Drinking, Washing or Cooking".

Toilet facilities will be provided in the number and type that meet Federal, State and local health requirements. These facilities will be maintained and the sewage disposed of in accordance with appropriate sanitary requirements under good public health practice and standards. (See Section 8, Chapter 5).

Reusable personal protective equipment will be sterilized before being issued to another person. Items requiring sterilization include safety glasses and goggles, rubber boots or shoes, rain suits or coats, hard hat bands, suspensions and winter liners, and shells for masks or respirators. Protective earplugs are considered expendable protective items.

All garbage or refuse will be disposed of in designated areas in a manner as stipulated by lease requirements and local or State regulations. See Section 9, Chapter 9, Solid Waste Control, for details.

Required washing facilities will be maintained in a sanitary condition and provided with adequate hot and cold water, soap, individual towels and re ceptacles for disposal of waste. Emergency showers and eyewash facilities will be provided as required.

H. Signs and Posters - Signs and posters of appropriate design and bearing standard pertinent regulations will be used to convey warnings, directions and instructions to personnel and the public, as required by the lease and other applicable regulations. The observance of such safety and accident-prevention signs will be strictly required of company employees and visitors while on the project.

I. Personal Protective and Life-Saving Equipment - Use of such protective equipment will be complied with as required by regulations and recommended by safety standards. Hard hats, hard-toed shoes, safety belts, goggles, respirators, earplugs and other personal protective equipment will be required where needed. Employees are expected to be responsible for the use and care of this equipment. Life preservers, work vests, ring buoys, nets, safety skiffs or other marine life-saving equipment will be provided for use of personnel working adjacent to or over water.

J. Protection of the Public - Project areas will be examined for hazards to the public, and suitable controls will be established to prevent access by the public to such hazardous areas as contaminated water storage ponds, unstable slopes, haul roads, construction areas, etc. Suitable access to safe water impoundments and nonoperating areas will be provided to encourage safe use of the area by the public.

A visitor's view point will be provided to allow the public to safely view operations.

CHAPTER 3

FIRE PREVENTION AND CONTROL

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 3
FIRE PREVENTION AND CONTROL

Fire prevention and control is of particular importance in the project construction, mining and processing activities, due to the unusually large concentrations of explosives, flammable liquids and combustible materials in a relatively confined area. The plan outlined in this chapter includes preventive measures, emergency procedures, applicable codes and regulations and training methods involved in establishing and administering an effective fire prevention and control plan for oil shale mining and processing operations.

The Rio Blanco management will designate a member of the supervisory staff as the project fire control coordinator--to be responsible for the operation of the fire prevention and control plan.

3.1 APPLICABLE REGULATIONS

Recommended practices and standards of the National Fire Protection Association and applicable Federal and Colorado fire protection and prevention regulations will be followed in the development and application of project fire prevention and control programs. A listing of the principal applicable regulations follows:

- Tract C-a Oil Shale Lease
- Fire Protection Handbook, National Fire Protection Association, Thirteenth Edition, 60 Batterymarch Street, Boston, MA 02110.
- National Fire Codes, National Fire Protection Association, 1975 Edition, 470 Atlantic Avenue, Boston, MA 02210.
- Colorado Mining Laws, Bulletin 20, Colorado Bureau of Mines, 1845 Sherman Street, Denver, CO 80203.
- Title 30, Part 55, Health and Safety Standards for Metal and Non-metallic Open Pit Mines, Bureau of Mines, U.S. Department of the Interior.

- Title 30, Part 56, Health and Safety Standards - Sand, Gravel, and Crushed Stone Operations, Bureau of Mines, U.S. Department of the Interior.
- Title 29, Part 1926, Sub-part F, Construction Safety and Health Regulations, Occupational Safety and Health Administration, U.S. Department of Labor.
- Safety and Health Rules and Regulations, Colorado Occupational Safety and Health Administration.

3.2 CONSTRUCTION

Fire prevention during construction is of particular concern because of the varied, widespread and scattered types of activities and the number of people and equipment items involved. Also, many of the subcontractors and tradespeople working on the project may be unfamiliar with fire prevention procedures and rules.

A. Tools and Equipment - A supply of fire fighting tools and equipment will be furnished to each construction site. These items must be kept at the respective construction sites at all times during project construction. They will be so located as to be readily accessible for fire use, and they will be reserved and used exclusively on fires and not in construction operations. Fire boxes will contain enough tools to adequately equip the men employed by the contractor during any given 8-hour shift. One fire box, normally containing 5 round-pointed shovels, 2 double-bitted axes, and 3 pulaskis or mattocks, will be provided for each 10 men.

Chain-saw crews and dozers working anywhere on the project will be immediately available for fire control within the project area.

B. Special Precautions - The following special precautions will be taken:

- Blasting - During the precautionary period (generally May 15 through November 15), a watchman, equipped with a size 0 or larger round-pointed shovel, will patrol the blasting area looking for fires.

- Welding - Welding will be accomplished in construction camp services areas when possible. If welding is required at a field location, it will be performed at a location where all flammable material has been cleared away for a distance of 15 feet around the area. One filled backpack pump, a shovel and an axe will be maintained at each welding site during welding operations.
- Spark arrestors - All diesel- and gasoline-powered engines, both mobile and stationary, will be equipped with approved serviceable spark arrestors. Exhaust-driven turbochargers are efficient spark arrestors.
- Lunch and warming fires - The building of open lunch and warming fires will be prohibited.
- Smoking - During the normal precautionary period (May 15 through November 15 as recommended by the U.S. Forest Service), smoking will be permitted only in safe places, such as along roads, in truck cabs, or in designated areas where all flammable material has been cleared away. Smoking will not be permitted in buildings containing gasoline, diesel fuel, oil or explosives, and "No Smoking" signs will be posted in such buildings.
- Power saws - Each gasoline power saw will be provided with a muffler in good condition. Each saw operator will have one chemical-pressurized fire extinguisher of not less than 8 ounces by weight and one size 0 or larger round-pointed, long-handled shovel. Spill proof metal cans will be used for refueling.
- Storage and parking areas - Areas for construction support facilities, equipment service, parking, gas and oil drum storage and explosive storage will be cleared of all flammable materials for a distance of 50 feet. Small stationary engine sites will be cleared of all flammable materials for a distance of 15 feet. Flammable and explosive storage areas will be labeled as such, and "No Smoking" signs will be erected.
- Oil filters, cartridges, and oily rags - Used and discarded oil filters, cartridges and oily rags or waste will be taken to an approved sanitary landfill. Glass jugs or bottles will not be used as gas, oil or waste containers.

C. Open Burning - Open burning is not contemplated as general practice on the project, and any open burning will require specific application to and approval of the Area Oil Shale Supervisor. However, in the event that such burning is required and approved, the following controls will apply:

- No burning will be allowed without advance approval of the project fire control coordinator. All verbal approvals will be confirmed in writing. Before burning is authorized, weather forecasts will be secured from the U.S. Weather Bureau. No burning will be permitted during turbulent weather conditions, or when a jet stream is within 50 miles of the burn site.
- A burning permit will be obtained from the Colorado Air Pollution Control Division prior to any burning. A copy of the permit will be filed by the project fire control coordinator.
- The coordinator may require burning in one area to be completed and extinguished before burning is started in another area. Based on the National Fire Danger Rating System, if Manning Class III or above is reached, mop-up of unextinguished piles will be immediate and complete, and followup checks will be made the next day to ensure that all fires are "dead out". The project fire control coordinator will determine from appropriate agencies when Manning Class III is reached.
- Fires started in the morning will be allowed to burn out by noon the same day and mopped up so as to be "dead out" before quitting time that day.
- A tractor with blade will be available during all burning to widen fire lanes and to stop advancing fires as necessary.
- The burning of any material will be done within a cleared right-of-way to the extent possible. All debris will be piled into large, compact, dirt-free piles for burning.
- A fire lane to mineral soil, not less than 12 feet wide and with 20 feet of the pile, will be constructed completely around each pile of debris under all conditions, except when there is snow cover of 4 inches or more.

3.3 PROCESSING FACILITY

The fire prevention and control plan for both the Phase I and Phase II processing facility incorporates a four-fold approach:

- Engineering design and plant layout to minimize the likelihood and severity of fire occurrence.
- Training program to instruct all plant personnel in normal plant operation, as well as in fire fighting procedures and details of the fire prevention and control plan.
- Adequate fire fighting equipment available throughout the processing facility for use by trained personnel, together with an effective communication system to coordinate fire fighting efforts.
- Safety program incorporating regularly scheduled inspection of processing facility operating and fire fighting equipment.

The major considerations and guidelines for fire prevention and control in the processing facility are described below.

A. Plant Design and Layout - Design specifications for all processing equipment and storage facilities will either meet or exceed the requirements of the Tract C-a lease and recognized standards for the oil refining industry. The principal non-governmental agencies that supply codes, standards and other widely accepted industry practices include:

American Petroleum Institute (API)
American Institute of Steel Construction (AISC)
American Society of Mechanical Engineers (ASME)
American National Standards Institute (ANSI)
American Concrete Institute (ACI)
American Society for Testing and Materials (ASTM)
Hydraulic Institute
Institute of Electrical & Electronics Engineers (IEEE)
National Electrical Manufacturers Association (NEMA)
National Fire Protection Association (NFPA)
Oil Insurance Association (OIA)

In addition, the design and construction of the plant will conform to the safety requirements of the latest editions of codes and regulations of the Federal, State or local agencies having jurisdiction.

1. Process Units - Process vessels, pumps, piping and associated equipment will be designed to withstand temperature and pressure conditions in excess of the normally expected operating conditions. These design conditions allow for temporary excursions from normal conditions and reduce the probability of equipment failure before corrective measures can be taken. Construction materials will be selected specifically for the process fluids involved, and corrosion allowances will be included to provide extra metal thickness for potential corrosive attack over the life of the process units. To the maximum practical extent, automatic controls will be installed that will operate in a fail-safe manner, thereby minimizing dependence on the human element. Indicating, recording and controlling devices monitoring pressures, temperatures and flow rates will be integrated with all processing equipment. In addition, alarms and shutdown systems will be used to warn of unusual process conditions and to shut down operation before equipment failure can occur. All of these devices will serve to maintain proper operating conditions and to prevent occurrences that might result in explosions or release of flammable materials from the process units.

Process unit layout is an essential part of controlling and minimizing loss from potential fires. The plant layout follows modern refinery practices and is in accordance with insurance underwriters' recommendations. Some considerations relative to the process unit plot plan are listed below:

- Administration buildings, medical buildings, fire station and utility areas will be located so that they will not become involved in a fire or explosion originating in the processing or tankage area.
- Storage tanks will be located so that, in the event of failure, their contents cannot flow by gravity to feed a fire in a process or service area.
- Spacing between process units will be at least 50 feet to permit maintenance and hot work to be performed while adjacent units are

operating and to minimize mutual involvement of process units in case of fire.

- In locating flares, consideration will be given to wind direction, exposure to adjacent equipment and heat release. Elevated flares will be at least 100 feet above grade and a minimum of 200 feet from operating plants.
- Fire drill equipment and training area will be located downwind of the plant with a minimum clearance of 200 feet from property lines and operating equipment. The area reserved for this purpose will be at least 100 feet square, adjacent to a road and accessible to water supply.
- Access for fire trucks and associated equipment will be provided to all process areas.

Within the battery limits of a single process unit, the following guidelines for equipment location will apply:

- No smoking will be allowed.
- Storage tanks containing flammable material will not be located within battery limits.
- Control houses will be located at the edge of battery limits at least 100 feet from fired heaters.
- Fired heaters will be at least 50 feet from processing equipment handling light hydrocarbons. Individual furnaces will be at least 25 feet apart. Boilers will be located as far from process units as practical.
- Air-cooled exchangers will preferably be located in a clear area with no equipment underneath that might be involved in a fire.

In addition, fireproofing up to 30 feet above grade will be provided on main structural supports for vessels, towers and pipe racks located within processing areas.

2. Storage Facilities - Facilities for storing large quantities of hydrocarbons will be designed to minimize the possibility of fire and spillage.

The layout and construction of storage tanks will follow the requirements of the Tract C-a lease, as well as recommendations and standards set by the NFPA and the API. Fabrication materials for storage tanks will be selected specifically for the fluid to be stored.

All product and intermediate storage tanks will be situated in a tank farm, which will be segregated from the processing areas. Spacing between adjacent tanks and between tanks and process areas will be in accordance with the appropriate NFPA codes or local regulations, as a minimum. In general, the clear distance between tanks will be one-half the greatest dimension of the smaller tank. This clearance will enable fire fighting equipment and personnel to safely approach and control a tank fire. In addition, cooling water streams can be directed at tanks adjacent to one involved in a fire to prevent overheating and structural damage to the adjacent tanks.

All tanks, situated singly or in groups, will be surrounded by dikes, which will form spill containment basins. The dikes will be engineered in accordance with requirements of the lease and NFPA standards, as a minimum, and will serve to reduce the possible spread of fire outside the originating diked area. Interior surfaces of diked areas will be impermeable, and each area will be designed for drainage of spills away from tanks into a gathering basin. The dike height will be kept as low as practicable to contain the desired volume of storage, with a maximum height of 6 feet set to avoid obstruction of fire fighting equipment. Furthermore, dikes will be located so that fire fighting equipment will have access to any tank with not more than one dike intervening. Also, no smoking will be allowed in tankage areas.

B. Plant Inspections - Periodic inspections of process equipment and tankage will be made as part of the plant maintenance program. While primarily designed to avoid unscheduled downtime and maintenance, these inspections will also serve to detect and prevent potentially hazardous conditions arising from equipment failure. Radiographic and ultrasonic techniques will be used to examine the condition of pressure vessels, furnace tubes, storage tanks and piping while process units are on-stream. Combined with internal inspections made on maintenance turnarounds, these examinations will provide corrosion histories for each piece of equipment so that replacement schedules can be established. This procedure will ensure that equipment items are removed from service before normal wear can result in catastrophic failure.

Unscheduled plant inspections will be made regularly by the plant safety committee to check on general adherence to safe practices in daily operation. Irregularities and potential hazards will be reported to line supervisors, as well as plant management for corrective action. The plant fire teams will assume responsibility for regular inspection of all fire fighting equipment.

C. Fire Protection Equipment - The principal fire fighting agents will be water, foams, dry chemicals and steam. The fire protection system will be designed so that the agents needed in a particular fire situation will be available in the right places and in quantities sufficient for rapid containment. In setting the size of the fire protection system, the "single-risk concept" will be employed. This concept is based on the assumption that there will be only one major fire in the processing facility at any given time and that that fire will be confined to a single fire risk area. Essentially, the total capabilities of the fire protection system can be employed against that fire.

D. Fire Protection Water System - The system and equipment for supplying fire protection water will be designed in accordance with recommendations of the National Board of Fire Underwriters. A tank with a storage capacity capable of supplying the fire protection water requirements continuously for 6 hours will be provided. Pumping capacity will be provided by two or more pumps, rated for 150 psi discharge to maintain minimum hydrant pressure of 100 psi at design flow. For optimum reliability, different types of pump drives will be used. While electric motor driven pumps are most suitable for remote or automatic starting, at least one pump will be equipped with an internal-combustion drive.

Fire protection water will be distributed throughout the processing facility by an underground system of fire mains in a grid and loop configuration. Sufficient block valves will be provided in the mains so that sections of the system can be isolated without undue interruption of the fire protection capability. All piping and connections to monitors and hose reels will be protected against freezing.

Hydrants will be located so that any major piece of equipment will be covered by at least two hydrants. In general, a spacing of 150 to 300 feet will be maintained between hydrants. Fixed monitors in processing areas will be spaced 150 feet apart and positioned so as to be accessible during a fire. Hydrants and monitors will be located at least 50 feet from any equipment to be protected. Fixed water spray or deluge systems will be used to protect facilities where application of water would be difficult or dangerous, as well as isolated or unattended facilities and storage areas where delayed application of water could result in serious fire losses.

The fire protection water storage capacity and number of pumps required for the processing facility in Phases I and II are tabulated below.

Phase	Storage Capacity (million gallons)	Number of Pumps	
		Rated at 1000 gpm	Rated at 2000 gpm
I	1.1	1	1
II	2.4	2	2

E. Major Equipment - Specially designed and equipped fire trucks will be provided to combat oil fires. These trucks will be capable of pumping volumes of foam solution for storage tank and spill fire protection. Supplementary quantities of foam concentrate will be stored in mobile tank trucks or trailers for use where needed.

The processing facility will have available one or more fire trucks, equipped with 1000 to 1500-gpm water pumps and automatic foam proportioning equipment and capable of carrying 500 to 1000 gallons of 3% foam concentrate. At least one unit will be a combination foam-dry chemical truck capable of delivering dry chemical either alone or simultaneously with foam or water. The supplementary foam storage capacity will equal the foam capacity of the fire trucks. This storage capacity is based on the delivery rate required to extinguish a fire in the largest cone roofed tank. A suitable building or shelter will be provided to house and service mobile fire vehicles and miscellaneous fire equipment. This facility will be located along a main plant road in a safe area, remote from the processing areas, but convenient to fire fighting personnel.

Hose carts will be provided to get cooling water on equipment quickly and to supplement hoses carried on fire trucks. One or more hose carts will be located in each fire risk area, depending on the quantity of water that can be applied from monitors and other equipment.

Two-wheeled, pull-type foam carts, which can be easily handled by one man, will be provided at selected locations in the processing facility. These carts will be stocked with a drum of foam concentrate and an inline proportioner to operate from hydrant water. Turret nozzles and hydrants will be strategically located throughout the processing area.

Portable extinguishers will be provided for immediate use on fires at their incipiency. Dry-chemical extinguishers will be located in process areas, laboratories, buildings, pumping areas and similar locations where Class "B" fires may occur. Travel distance to a single extinguisher will be not more than 50 feet. One or more two-wheeled, 150-pound, dry-chemical extinguishers will be provided for each fire risk area. In addition, carbon dioxide extinguishers equipped with non-conductive discharge horns will be provided for protection of electrical equipment.

Cone-roofed storage tanks will be equipped with piping connections designed for subsurface injection of foam. This technique, the most recent development in foam application for fighting tank fires, is fully endorsed by the NFPA. Portable foam towers will also be provided for pumping foam over the top of tank shells directly onto the oil surface.

All fire fighting equipment will be regularly tested and maintained in first class operating condition. Records will be kept to ensure that maintenance of all equipment is performed on schedule.

F. Communication System - An in-plant system for emergency communication is essential--to alert and call personnel in the event of a fire or other hazardous situation, to inform personnel of actions required, to receive and transmit reports at the scene of an emergency, and to call and coordinate efforts with outside groups that will provide aid. To ensure rapid notification and sounding of the plant fire alarm, a separate telephone number will be assigned for fire reports, and a separate telephone, equipped with a loud alarm, will be provided at a constantly manned point to receive emergency calls. The plant siren, coded to designate the general area of emergency, can be actuated from this point. Manually operated fire alarm boxes, designed to activate the plant siren and provide coded information as to the location of an emergency, will be strategically located. Telephone call lists will be established to summon aid when manpower is limited. Walkie-talkies and two-way radio equipment will be provided in fire vehicles to help coordinate fire fighting efforts. These backup systems are essential in the event the plant telephone system is damaged.

3.4 MOBILE EQUIPMENT

All self-propelled mobile equipment will be provided with suitable fire extinguishers. In addition, some specialized equipment will be provided with special extinguishers, as follows:

- One portable fire extinguisher having a rating of at least 20 BC units will be provided on all tank trucks or other vehicles used for transporting flammable liquids.
- A fire extinguisher with a 5 BC rating or higher will be placed in a readily accessible location at the operator stations or cabs of cranes, derricks, hoists, elevators and conveyors.
- Self-propelled vehicles used to transport explosives or detonators will be equipped with a fire extinguisher with a rating of not less than 10 ABC units.
- The mobile fire fighting equipment that will be available for use in emergencies occurring during Phase I operations is listed below. (Additional equipment will be provided for Phase II.)
    - One fire truck (1000-gpm pumper) equipped with foam equipment, as described above.
    - One fire truck (500-gpm pumper) with foam equipment.
    - One foam-concentrate storage trailer.

Equipment, normally used for operation, which will be available for fire fighting includes:

- Three 14,000-gallon water trucks equipped with pump and fire hoses.
- Dozers and graders.
- Front-end loaders.

3.5 STOCKPILES

Stockpiles will be located at least 50 feet from all buildings and other facilities, and accessways (at least 12 feet wide) will be maintained around and between stockpiles to permit the approach of fire control equipment. Dozers, loaders and water trucks will be used to expose and extinguish fires occurring within stockpiles.

3.6 CRUSHERS, CONVEYORS AND BAGHOUSES

In locations where fire would create a hazard to personnel, belt conveyors will be provided with safety switches to stop the drive pulley automatically in the event of excessive slippage.

A fire extinguisher, rated at not less than 10 BC units, will be provided inside or within 25 feet of the operating stations of all crushers and conveyors and outside, but within 25 feet of, each baghouse.

3.7 OFFICES, WAREHOUSES AND SHOPS

Combustible materials, grease, lubricants or flammable liquids will not be allowed to accumulate in areas where they can create a fire hazard. All rubbish and combustible trash will be kept in metal containers. Oily and greasy rags will be kept in covered metal containers.

Smoking will be prohibited at or in the vicinity of operations constituting a fire hazard, and "No Smoking or Open Flame" signs will be conspicuously posted. A fire extinguisher, rated at not less than 2 A units, will be provided for each 3,000 square feet of protected building area. At least one fire extinguisher, rated at 2 A units, will be located near the stairway on each floor of multi-storied structures.

Electrical wiring and equipment for light, heat and power sources will be installed in compliance with provisions of the National Electrical Code.

3.8 FUEL STORAGE AND DISPENSING

At least one fire extinguisher, rated at not less than 20 B units, will be located outside but within 10 feet of the door of any room used for storage of more than 60 gallons of flammable liquids. At least one fire extinguisher, rated at not less than 20 B units, will be located not less than 25 feet nor more than 75 feet from any outdoor storage area for flammable liquids.

Storage tanks containing flammable liquids will be separated. Spacing between adjacent tanks and between tanks and processing areas is described in Part 3.3A above. The storage area will be graded to divert possible spills away from buildings or work areas, and it will be surrounded by dikes, which will form spill-containment basins, as described in Part 3.3A above.

3.9 WELDING AND CUTTING OPERATIONS

Fire extinguishers, water hoses and other fire-fighting equipment will be located conveniently so that they will be ready for use in case of fire. Employees doing welding will wear fire resistant guantlet gloves and aprons of asbestos or leather, or equivalent material, as protection against heat and sparks. No employee will leave a torch until the oxygen and acetylene valves have been completely shut off.

Whenever practicable, all arc welding and cutting operations will be shielded by non-combustible or flame proof screens. When welding or cutting is such that normal fire precautions are not sufficient, additional personnel will be assigned to guard for fire. Welding or cutting will not be performed in atmospheres containing more than 1.0% of flammable gases.

Any container that has contained a toxic or flammable substance will either be filled with water or thoroughly cleaned of such substance and ventilated and tested before being welded, cut or heated.

Oxygen cylinders in storage will be separated from fuel-gas cylinders, reserve stocks or carbides, or highly combustible materials by a minimum distance of 20 feet or by a non-combustible barrier at least 5 feet high having a fire-resistance rating of at least 1/2 hour.

3.10 MANAGEMENT AND TRAINING

The objective of personnel training in the overall fire prevention and control plan is two-fold: 1) to provide instruction in safe procedures for normal operation of the facilities and in recognition and avoidance of potentially hazardous situations and 2) to provide instruction in the specifics of the fire protection plan and the use of fire-fighting equipment.

A. Training - All personnel will receive basic training, as well as on-the-job training, and will be tested to determine the knowledge level attained. Written manuals will be issued to the operators of each process unit covering: Normal procedures for startup, operation and shutdown; and special procedures for emergency shutdown and preparation of equipment for maintenance; and safe practices. The "unit" manuals will also provide detailed information on the process equipment controls. Line supervisors will be responsible for ensuring that operators perform in the approved, safe manner. The plant engineering and technical section, as well as the plant safety group, will assist in ensuring that the supervisors understand and accept this responsibility.

Fire fighting training will be given to all personnel at regular intervals to maintain familiarity with fire fighting equipment use and fire-fighting procedures. These training sessions will stress knowledge of the fire protection plan, which will detail procedures to be followed and assign duties to be performed by specific persons in case of a fire, major spill or other emergency. The detailed fire protection plan will include plot plans of processing units, indicating location of fire extinguishers, fire hydrants, foam connections and other equipment and facilities.

In-plant fire teams will be organized among personnel on duty for each shift, and a call out procedure will be used to obtain additional personnel, if required. Members of these fire teams will receive intensive, continuous training in actual fire fighting techniques at the fire training area. Operating supervisors, who will normally direct a fire attack, will be given special training by the plant fire chief in fire fighting techniques and strategy. This training will be supplemented by formal courses in fire fighting at accredited fire schools.

B. Emergency Procedures - A detailed fire control plan will be developed and implemented when final design is completed. Procedures will include those outlined in the plan, as well as the following:

- Emergency telephone numbers and notification procedures.
- Emergency communication procedures.
- List and location of fire-fighting equipment.
- Fire-alarm procedures and emergency evacuation plans.
- Arrangements for emergency first aid.

CHAPTER 4

NOISE CONTROL

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 4
NOISE CONTROL

Construction and operation of the RBOSP mining, processing and disposal facilities will generate significant amounts of noise. Facilities will be designed and operated to comply with the Tract C-a lease terms and applicable laws, standards and regulations.

4.1 REGULATIONS

Pertinent Federal and State of Colorado legislation concerning noise control has been reviewed, and project planning has been and will continue to be guided to ensure compliance. The principal legislation is:

- Noise Control Act of 1972 - Public Law 92-574.
- Environmental Protection Agency Regulations - 40 Code of Federal Regulations, Part 202, "Motor Carriers Engaged in Interstate Commerce".
- Colorado Revised Statute 73-12-101 et seq., "Noise Abatement".

4.2 NOISE LEVELS

It is not possible to predict, with any degree of accuracy, the overall noise levels to be expected from large construction, processing and mining operations. Typical noise levels from some of the noisier items of equipment that will be used are listed below:

Crusher	100 dbA
150-ton truck	96 dbA
Highway truck	85 dbA

As stated in Chapter 2 of this section, noise levels will be monitored for personnel health protection. Where feasible, equipment and machinery that produce lowest sound levels will be incorporated in the design of the facilities.

4.3 CONTROL METHODS

Much of the machinery used in crushing the oil shale in preparation for retorting will be enclosed to facilitate dust control. These enclosures will serve the second function of providing sound attenuation.

Mobile machinery will be equipped with customary exhaust controls to limit the noise emanating from these sources.

All motor carriers engaged in interstate commerce and under the control of this project will be equipped with adequate mufflers, properly designed tires and other equipment required to meet the limits established by law (86 dbA up to 35 mph and 90 dbA over 35 mph). General area noise levels are controlled primarily by CRS-73-12-101 et seq. The levels of sound permitted by this regulation are summarized below:

	Noise-Level Permitted (dbA)	
Zone	7:00 am to next 7:00 pm	7:00 pm to next 7:00 am
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial	80	75

Due to the remote location and the large areas involved, the public will not generally be subjected to excessive noise levels. Within the corridor for the processed shale and overburden haul roads, noise levels of 75 dbA will be experienced as much as 425 feet from the centerline of the haul roads. These noise levels will be drastically reduced in the Phase II operation when both overburden and processed shale will be transported to the disposal site by belt conveyor, rather than by large haul trucks.

Noise exposure of workmen will be controlled by the following techniques:

- Limiting exposure time.
- Providing individual protective equipment.
- Providing sound control enclosures.

CHAPTER 5

AIR QUALITY CONTROL

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 5
AIR QUALITY CONTROL

The Rio Blanco Oil Shale Project recognizes that preservation of the air quality of the Piceance Basin is of utmost importance. Thus, every reasonable effort will be made to control fugitive dust, to minimize particulate and gaseous emissions, and to maintain air pollutants at levels below the State and Federal standards. The best available control technology will be used. Soil stabilizers, dust retardants and surfactants, as well as modern suppression systems, dry-fabric collection designs, and high-efficiency wet scrubbers, will be employed to maintain the air quality of the Tract C-a area.

5.1 CONSTRUCTION

A. Roads - The soil in the Piceance Basin is light and breaks up into a very fine powder when disturbed by heavy traffic during the dry seasons of the year. Thus, proper abatement and preventive measures will be required to prevent unpaved roads and trails in the Tract C-a vicinity from creating large quantities of fugitive dust during the initial construction.

Traffic will be confined to specified roads, corridors and designated construction areas to minimize land disturbance. The use of off-road vehicles will be restricted to necessary areas of the construction sites.

During road construction, the trails, roads and parking areas will be watered frequently with trucks and/or sprinkler systems to allay fugitive dust. Dust palliatives, such as a polymer solution, latex solution or asphalt emulsion, will be used as required, to aid in preventing the soil from blowing. Unpaved road surfaces and parking lots may be treated with penetration chemicals, such as lignin sulfonate.

Haul road construction will be done in the same manner to minimize dust generation. Since haul roads will not be paved, continual use of water and soil stabilizing agents will aid in controlling dust and provide a surface that will minimize tire wear. Salt and sand may be required during freezing conditions.

B. Mine Site - Fugitive dust abatement and preventive procedures will be conducted on a continuing basis during development of the mine, primary crusher site and conveyor routes. Prewatering and wetting with sprinklers and water trucks will aid in controlling fugitive dust during initial mining activities. During the heavy construction activities involved in developing the sites, frequent watering and sprinkling will be provided to control the dust.

Treating with dust palliatives, such as oil emulsions, polymers, latex dust retardants and soil stabilizers, will help in controlling fugitive dust generation during construction and mining activities. Routing, speed control and closure of construction areas to extraneous traffic will reduce the total dust load in the airshed.

Construction vehicle activity will be restricted to the actual construction sites and access roads to aid in dust control. Coordinated development to disturb land only when necessary will reduce the windblown dust problems. Straw, matting and mulch from existing vegetation will be used if necessary to hold the soil from excessive blowing or washing until revegetation can take place. High winds which could aggravate the airshed particulate loading may occur during the late summer thunderstorm activity. Extra sprinkling and watering may be required during these times.

C. Processing Facility - Land disturbance around the process facility construction site will be minimized as much as practicable. Restricting the activity of off-road vehicles and construction equipment to the construction sites will reduce land disturbance and damage to the vegetative cover. The coordinated delivery of construction materials and machinery to designated storage areas will also reduce traffic and land disturbance.

During construction of the processing facility, continual dust control procedures will be conducted. The site access aisles will be watered frequently with water trucks to control fugitive dust around work areas. Sprinkler systems can be used to wet large storage areas, dikes and excavations. Compaction, with the possible use of dust palliatives and retardants, will be used to hold the soil from blowing until paving, revegetation or other permanent cover is in place. The processing facility lots and access aisles will be paved or covered with gravel as soon as the construction activities will permit. Landscaping and revegetation as necessary to hold the soil and control fugitive dust will be accomplished as construction of major portions of the processing facility is completed.

D. Processed Shale and Overburden Disposal Area - The sites selected for processed shale and overburden disposal will be stripped of soil. Stripping will be limited to only enough area to facilitate initial operations. Additional stripping will be done only as required by the disposal operation. Fugitive dust control methods for processed shale and overburden site development will be the same as those used for road construction and initial mining activities.

E. Support Facilities - The dust control procedures for construction of the support facilities will be the same as those used in other areas. The important techniques include minimizing land disturbance, watering and paving roads, sprinkling large disturbed areas, and enclosing or shielding dusty work places. Palliatives, retardants, soil stabilizers, mulching, matting and revegetation will be employed as the dust control situation demands.

F. Burning Control - Open burning of waste, timber, brush or construction debris will be used only as a last resort and must be authorized by the Area Oil Shale Supervisor. A permit must also be obtained from the Colorado Department of Health, Air Pollution Control Division. Control of burning is detailed in Chapter 3 of this section.

G. Construction Vehicles and Equipment - All gasoline and diesel powered equipment will comply with applicable emission regulations. Proper routine maintenance procedures for this equipment will be employed to reduce emissions.

5.2 MINING

Presently no data from open pit mining of oil shale is available for predicting particulate emissions. However, the control methods described are expected to hold particulate emissions to acceptable minimums. During the air quality monitoring program a site near the mine will monitor particulate emissions to determine the effectiveness of the particulate control methods.

A. Phase I - During open pit mine development, the standard dust control methods for site preparation outlined for the construction phase will be employed. In addition the measures described below will be used to allay the dust during the mining activities.

1. Drilling - The dust control method that will be used on the open pit blast hole drills consists of water injection. No dust will be emitted from the wet drilling operation. The water injection will be controlled manually by the drill operator to maintain a dust free operation, as well as aid in the drilling. An alcohol mix will be used during the winter months to protect the water injection system from freezing.

2. Blasting - The use of proper drill patterns, quantities of explosives and detonation practices will minimize fugitive dust generated during drilling and blasting operations. Blasting will be done at shift change so that blast ing effects will occur infrequently and will be of a short-term nature. Most of the dust generated by blasting operation is expected to settle back on the mine site.

3. Loading - The loading of oil shale into the haul trucks from the muck piles may create dust, the amount of which will depend on the moisture content and other characteristics of the oil shale ore. Spraying of the muck pile may be feasible to aid in minimizing dust during loading. The shovels which will be electric powered, will have no engine exhaust.

4. Hauling - The haul roads and disposal areas will be graded and treated as necessary to maintain a suitable dust-free surface for the heavy haul trucks.

The haul road surface must be somewhat pliable and contain the required amount of fine material to minimize tire wear. This fine material will be kept wet by sprinkling or treated with a palliative to bind the soil particles together to prevent them from becoming a source of dust. The various palliatives that may be used to augment the watering program are asphalt emulsions, polymer solutions, salt solutions and lignin sulfonate. Final choice of the palliative used will be subject to AOSS approval.

Loaded haul trucks can be passed under spraybars to wet the surface of the load. This measure, which will be most effective for long hauls with dry fine material, will be used if dust generated from the loads becomes significant. Periodic maintenance of equipment will reduce exhaust emission levels and improve performance.

B. Phase II - The Phase II mine will simply be a larger version of the Phase I mine. More equipment will be used and more oil shale will be mined, but the same dust control procedures will apply. Fugitive dust and particulate emissions from drilling, blasting, loading and hauling operations will be minimized in the same manner as in Phase I.

5.3 CRUSHING, CONVEYING AND STOCKPILING

The crushing, conveying and stockpiling of the oil shale ore are expected to generate a major portion of the dust and particulate emissions that will be generated during oil shale mining and processing. The emission source, quantities of dust generated and methods of control, as well as alternative solutions, are described for each major step in the materials-handling activities.

Estimates of emissions and control efficiencies for crushing, conveying, and screening are based on information from: confidential reports from TOSCO; equipment vendor's data; Oil Shale Air Pollution Control, EPA - 600/2/75-009, May 1975; and An Environmental Impact Analysis for a Shale Oil Complex at Parachute Creek, Colorado, Colony Development Operation, Volume 1, 1974.

A. Phase I - The estimated particulate (dust) emissions from the crushing, conveying and stockpiling operations for Phase I - Stage 2 are presented in Table 9-5-1. The estimated emissions with control are compared with the maximum emission rate allowed by the Colorado process weight rate regulation (Colorado Air Pollution Control Commission, Regulation No. 1). Phase I - Stage 2 was selected for modeling since this period involves the largest expected emission rates during Phase I.

1. Primary Crushing - During primary crushing the oil shale will be reduced from run-of-mine size to a minus 6-inch size. In Phase I one impact-type primary crusher will be used for ore. Sub-ore and overburden will be trucked to the disposal area without crushing. The dust generated by the primary crushing operation is estimated to range from 0.02% to 0.03% of the oil shale ore handled.

The primary crusher is enclosed and the dust-control device planned is a fabric filter dust collector baghouse, with a control efficiency of 99.8%.

The dust collected from the primary crushing facility by the baghouse will be slurried to the processed shale moisturizer. This disposal method will be used to lower emissions in the conveying and stockpiling of primary crushed oil shale. This control measure will result in the loss of only a small portion of the retort feed.

2. Conveying of Primary Crushed Oil Shale - The crushed ore from the primary crushing facility will be discharged onto a conveyor system for transport to the primary ore stockpile at the processing facility. The Phase I conveyor system will have three transfer points between the primary crusher and the primary ore stockpile. The conveyor will be covered, and it will have a dust suppression system at each transfer point for dust control. Suppression causes small dust particles to agglomerate into larger ones which do not easily become airborne. When suppression is used, the transfer point is not considered a source of particulate emission. The return belt will be cleaned with a brushing unit or scraper to prevent the accumulation of material under the conveyor. Other conveyor transfer points are located within the secondary

Table 9-5-1

PHASE I - STAGE 2 CRUSHING, CONVEYING AND STOCKPILING
ESTIMATED PARTICULATE EMISSIONS

	Primary Crushing	Primary Stockpiling	Primary Ore Reclaiming	Secondary Crushing	Fine Ore Storage
Material Handled (TPH)	1,530	1,530	1,142	1,142	1,139
No. of Stacks	1	1	1	3	2
Stack Height (ft.)	120	122	122	120	120
Stack Diameter (ft.)	3	1.5	1.5	3	1.25
Gas Flow Rate (ACFM)	15,000	3,500	2,500	33,500	4,000
Exit Temperature (°F)	TA* + 60	TA + 60	TA + 60	TA + 60	TA + 60
Control Device	Baghouse	Baghouse	Baghouse	Baghouse	Baghouse
Control Device Efficiency (%)	99.8	99.0	99.8	99.8	99.8
Estimated Emissions with Control (PPH)	1.8	3.1	2.0	13.7	2.7
Colorado Weight Rate Emission Limit (PPH)	55.9	55.9	53.4	53.4	53.4

*TA Temperature Ambient

crushing facility or the processing facility and dust collection will be incorporated into systems provided for those facilities.

3. Stockpiling of Primary Crushed Ore - The open pit primary ore stockpile will be built by employing a 100-foot tall by 12-foot inside diameter concrete tower. It will have rectangular openings at different levels, as well as a bottom discharge chute. Each opening will have a hinged flap to allow ore to flow out. The tower will keep the material stream enclosed and prevent the wind from blowing fine ore particles as they drop from the conveyor belt. A baghouse dust collector will be installed atop the tower to provide dust control for the conveyor and tower. Collected dust will be slurried to the processed shale moisturizer. A slight negative pressure will be maintained to contain the dust in the tower as the rock rolls through the openings. The removal of the dust at the primary crusher, the residual moisture from preceeding suppression, and a feed-through tower design aid in reducing the dust generation.

Dust production is estimated at 0.01% of the material deposited. An overall dust control efficiency of only 99% is assumed because of the exposed stockpile area. Water sprays will be applied to the open pile if it becomes necessary.

4. Reclaiming from Primary Crushed Ore Stockpile - The ore reclaiming operation in the reclaiming tunnel beneath the primary stockpile will be a source of dust. The ore reclamation rates will be governed by the secondary crusher feed demand. The reclaiming equipment and belt conveyors will generate dust in the range of 0.04% to 0.05% of the oil shale handled. The dust-laden air will be drawn through a centralized dust collection system, and a baghouse will provide the required dust control. Again, the collected dust will be slurried to the processed shale moisturizer.

5. Secondary Crushing and Screening - The secondary crushing and screening facility will consist of multiple crushing, screening and conveying systems. Stage 1 will have two crushers and Stage 2, four crushers, all contained in the

same building complex. The ore will be reduced from a nominal 6-inch size to a minus 3/8-inch size by an impact-type crusher. The dust generated at the distribution bin, by the vibrating feeders, vibrating screens, crusher and conveyor feed points will be controlled by a baghouse dust-collection system. One baghouse will be used for each crusher and collected dust will be placed back on the conveyor feeding the fine ore storage silo. Hoods, enclosures and rubber curtains will help minimize dust emission from the equipment. The crusher building will be maintained under a slight negative pressure to contain the dust within building.

The dust generated by the secondary crushing and screening facility is estimated to be 0.30% of the oil shale ore processed. The production rate for the secondary crusher operation will depend on retort feed requirements.

6. Fine Ore Storage - The fine ore from the secondary crushing facility will be conveyed to the fine ore storage bin and also to an open, emergency stockpile. One storage silo will be used for Stage 1, and a second bin will be added for Stage 2. The open stockpile will be used only for upset conditions and testing purposes. If necessary, the open stockpile will be sprayed with a polymer or latex retardant solution, which will form a thick crust and prevent erosion by wind or water.

Since the moisture content of the minus 3/8-inch oil shale will be low and no dust suppression is anticipated, the fine ore storage bin will have a dry dust control system. The dust generated at this point is estimated to amount to 0.06% of the fine ore feed stock handled. A conventional silo or storage bin dust collector system will be used. A baghouse will be used on the inlet and discharge points of the bin for dry collection of the dust. The collected dust will be deposited on the conveyor belts feeding the retorts.

B. Phase II - The dust and particulate emission control techniques used during Phase I will be used on a larger scale for Phase II. Dry fabric filter collection, suppression and retardants will be employed to minimize the dust

dust during the various steps of the expanded oil shale crushing, conveying and stockpiling operations for Phase II.

The estimated particulate emissions for Phase II crushing, conveying and stockpiling operations are presented in Table 9-5-2. The estimated emissions with control are compared with the Colorado process weight rate emission limit.

1. Primary Crushing - The expanded mining plan for Phase II calls for primary ore, sub-ore and overburden crushers to be located at the open pit mine site. The primary crusher will reduce the mined ore to minus 6-inch size for further processing. The sub-ore and overburden crushers will reduce the sub-ore and overburden rock to minus 12 inches, a size easily handled by large conveyors. The emission rates of the dust generated by the three crushers are estimated to be 0.03% of the ore and rock handled. The hourly production rate for the Phase II mining plan was used for the emission calculations. The dust control device planned is a baghouse dust collector with a control efficiency of 99.8%. Collected dust will be slurried to the processed shale moisturizer.

Dust suppression is an alternative method of control. It will be used as a back-up control system on the primary ore crusher, but it will be used as the main dust control means for the sub-ore and overburden crusher.

2. Conveying of Ore and Overburden - Three conveyors will be used to transport the primary ore, sub-ore and overburden in Phase II. The sub-ore and overburden will be conveyed to their separate disposal areas instead of being hauled by truck. All of the conveyors will be covered to minimize the blowing of dust from the load. The return belts will be cleaned with a brushing unit or scraper at each transfer point. There will be about 12 transfer points in the conveyor system. All the conveyors used for primary ore, sub-ore and overburden will employ dust suppression at the transfer points to prevent particulates from becoming airborne.

Table 9-5-2

PHASE II CRUSHING, CONVEYING AND STOCKPILING
ESTIMATED PARTICULATE EMISSIONS

	Primary Ore Crushing	Sub-Ore Crushing	Overburden Crushing	Primary Crushed Ore Stockpiling
Material Handled (TPH)	5,420	800	4,100	5,420
No. of Stacks	1	1	1	No Stack
Stack Height (ft.)	30	30	24	30
Stack Diameter (ft.)	2.8	2.5	2.3	NA*
Gas Flow Rate (ACFM)	15,000	12,750	8,500	NA
Exit Temperature (°F)	TA** + 60	TA + 60	TA + 60	TA + 60
Control Device	Baghouse	Baghouse	Baghouse	Suppression
Control Device Efficiency (%)	99.8	99.8	99.8	99.0
Estimated Emission with Control (PPH)	6.5	1.0	4.9	5.4
Colorado Weight Rate Emission Limit (PPH)	68.5	50.4	65.5	68.5

	Primary Crushed Ore Reclaiming	Secondary Crushing	Tertiary Crushing	Fine Ore Storage	
				TOSCO	GCR
Material Handled (TPH)	4,482	4,482	2,900	2,900	1,582
No. of Stacks	No Stack	3	10	2	2
Stack Height (ft.)	30	120	120	120	120
Stack Diameter (ft.)	NA	4.6	3.9	1.0	1.0
Gas Flow Rate (ACFM)	NA	66,750	217,250	2,250	2,250
Exit Temperature (°F)	TA + 60	TA + 60	TA + 60	TA + 60	TA + 60
Control Device	Suppression	Baghouse	Baghouse	Baghouse	Baghouse
Control Device Efficiency (%)	99.0	99.8	99.8	99.8	99.8
Estimated Emission with Control (PPH)	8.4	29.0	33.0	6.6	3.5
Colorado Weight Rate Emission Limit (PPH)	66.4	66.4	62.0	62.0	56.3

*NA - Not Applicable
**TA - Temperature Ambient

3. Stockpiling of Primary Crushed Ore - The Phase II primary stockpile will consist of two open piles, which will extend 2,500 feet in length. The piles will be built to the height of 60 feet from an adjustable stacker boom. The stacker, which will be movable, will travel the length of the piles.

Dust control for this stockpiling operation will be accomplished by suppression systems mounted on the stacker boom and on the stacker conveyor systems. A fine mist will be sprayed over the ore as it is discharged from the stacker. The distance between the boom and the pile will be minimized by an adjustable stacking spout to reduce the dust emission.

An estimate of dust produced is 0.005% of the oil shale ore stockpiled. A dust control efficiency of only 99% is assumed because of the suppression system and the large exposed stockpile area.

If additional dust control is required for the static portions of the primary stockpile, a dust retardant (such as a polymer or latex solution) will be sprayed on the top and sides of the pile. This retardant will bind the fine ore dust particles and keep them from becoming airborne.

4. Primary Ore Reclaiming - The ore reclaiming will be done by a bucket reclaimer on an adjustable boom. The bucket reclaimer will also travel between the two primary stockpiles for their total length. It will gather ore with a bucket wheel and deposit it into a traveling hopper, which will then feed the ore conveyor belts leading to the secondary and tertiary crusher facility.

The reclaimer operation rate will be determined by the secondary and tertiary crusher demand. The reclaimer will generate dust in the range of 0.01% of the handled material. Dust suppression will be the means of control for the bucket reclaimer area, conveyor transfer points and traveling hopper. A cover made of belting material will be used on the long reclaimer conveyor.

5. Secondary Crushing - The secondary crushing facility will prepare the ore for the gas combustion retorts (GCR's) in Phase II. The primary ore will be reduced to a minus 2 1/2-inch size for GCR feedstock. The smaller material

will be screened out and sent on to the tertiary crushing facility. The GCR feedstock will not be crushed nearly as much as the TOSCO feedstock; consequently, the emission rate will be lower. A range of 0.16% of the ore is estimated for the secondary crushing-screening and handling operation. Dry dust collection using baghouses will be the means of control. The fine dust collected will be returned to conveyor lines to be used as TOSCO feedstock material.

6. Tertiary Crushing - In tertiary crushing, the fines and small ore left over from the secondary crushing and tertiary screening operations will be reduced to a minus 3/8-inch feedstock for the TOSCO retort. This third crushing will produce the same size product as produced by secondary crushing in Phase I. The dust generation is estimated to be 0.28%, as in Phase I. The amount of material handled will be less since a portion will have been used for GCR feedstock. A fabric dust collector system will be used for control and collected dust will be placed on the conveyor feeding the fine ore storage facilities.

7. Fine Ore Storage - Two fine ore storage facilities will be provided in Phase II. One will handle the minus 2 1/2-inch feedstock for the gas combustion retorts, and the other will handle the minus 3/8-inch material for the TOSCO retorts. Both facilities will consist of a long, enclosed hopper, which will have a dust collection system for the inlet and discharge points. The same control techniques will be used as are described for Phase I.

The dust generated at the two fine ore storage facilities is estimated at 0.06% of the feedstock produced in each case. The collected dust will be deposited on the conveyor belts feeding the retorts. No open fine ore stockpile is presently planned for Phase II.

8. Alternative Dust Control Techniques - An alternative to a dry collection baghouse system, and perhaps a more economical control device, is a wet scrubber. Control efficiencies of greater than 99.8% could be expected from these devices. The wet scrubber would require large quantities of water, however, and a system to remove the resulting slurry. Freezing conditions during the winter would lower the collection efficiency due to ice buildup.

Present concern to minimize water consumption, and uncertainty about cold weaterh operations precludes the use of the wet scrubber on the crushing, screening and conveying systems at this time. An alternative for dust control around stockpiles is to spray them with a polymer or latex dust-retardant solution, which will form a thin crust. This crust, made up of the retardant and ore particles bound together, would prevent the wind from eroding a stockpile. When the stockpile surface is disturbed or more ore is deposited, another application of the retardant would be required.

9. Design Criteria - To assure the quality and effectiveness of dust control and ventilation in crushing and material handling, certain minimum levels of air movement must be maintained. The following list summarizes the design criteria that will be used on the Rio Blanco systems design.

Item	Ventilation Requirements
Belt conveyor transfers	Hooded with 500 cfm per foot of belt width
Belt wipers	Hooded with 200 cfm per foot of belt width
Feeder chute to conveyors	Hooded with 500 cfm per foot of belt width
Bins	Connect exhaust to bin top away from feed point, 200 fpm through open feed points
Bin feedout to conveyor belt	Hooded with 500 cfm per foot of belt width
Conveying velocity	3500 fpm in all ducts
Indraft velocities	Base on 200 fpm minimum
General hooding design	Principle of minimum openings in hoods will be adhered to. Hinged hoods will be used where occasional access is required.
Screens	Minimum indraft of 200 fpm through hood on cover openings.

10. General Design Notes - Gas cleaning will be done by means of fabric filters, commonly called baghouses. Where special problems of moisture or sticky dust are encountered, high-efficiency wet scrubbers may be used. Baghouses handling oil shale dust will be provided with explosion relief ports. All gas cleaning systems will be arranged so that the exhausts or fans will be

located on the clean air side of the gas cleaning device. All dust control system fans will be direct-drive to improve reliability and reduce maintenance.

5.4 PROCESSING

The Air Quality Control Plan for the Phase I and Phase II processing facilities involves aspects of plant design, operation and maintenance. The plant design is oriented toward control of emissions of sulfur dioxide, nitrogen oxides, trace hydrocarbons, and particulate matter to the atmosphere. Systems included in the processing facilities for this purpose are described in Section 6 and are reviewed below specifically for those aspects relating to air quality control. Guidelines for operation and maintenance have been developed to insure proper performance of these control systems during operation of the processing facilities.

A. Phase I

1. Plant Design - The processing facility is designed to control atmospheric emissions from two major sources:

- fired heaters and boiler stacks
- process stacks

Control of emissions from heaters and boilers is accomplished by using a purified gas to supply the fuel requirements of the facility. Desulfurization is carried out in the sulfur recovery plant where about 98% of the sulfur compounds in the untreated gas are removed. Ammonia, which can form nitrogen oxides in combustion systems, is removed from the gas to the extent of about 99% by contact with water in the raw oil recovery and high BTU gas plants. The use of the purified gas as fuel provides low emissions of trace hydrocarbons and particulate matter since more complete combustion can generally be obtained in heaters and boilers with gaseous fuels than with liquid fuel oils.

The most important process stacks in the Phase I processing facility are located in the TOSCO II retorting plant, specifically the preheat, ball circulation, and shale moisturizing system stacks. The preheat system is fired with purified fuel gas but the flue gas picks up shale dust and trace hydrocarbons as it passes through the system. An incinerator is provided to remove 90-95% of these hydrocarbons by combustion. The flue gas then passes through a high energy venturi scrubber to remove 99.6-99.9% of the entrained dust.

The ball circulation system uses flue gas from a steam superheater fired with purified gas to remove shale dust from ceramic balls. Dust entrained in the flue gas is trapped in a high energy venturi scrubber. The shale moisturizing system generates steam during the process of adding water to processed shale. The vapors are passed through a high energy venturi scrubber to remove entrained shale dust.

Water recovered from the raw oil recovery, thermal cracking, and high BTU gas plants contains dissolved hydrogen sulfide and ammonia. This water is steam stripped and the evolved gases are treated in the sulfur recovery plant to remove about 99.5% of the contained hydrogen sulfide. Ammonia containing residual gas, spent regeneration air from the sulfur recovery plant, excess fuel gas and API separator sludge are burned in a thermal oxidizer. The ammonia containing gas is handled in a special burner in the oxidizer to minimize formation of NO_x from ammonia.

Estimated Phase I - Stage 1 processing facility emissions are presented in Table 9-5-3, for Stage 2 the Stage 1 estimates are doubled. Emission standards applicable to the processing facilities are found in Colorado Air Quality Regulations 1 and 6 and in the EPA New Source Performance Standards.

Colorado Regulation 1 restricts particulates and SO_2 emissions from fuel burning equipment and particulates from solids handling equipment. For the fuel gas used in the Phase I facilities, particulates emissions are 0.02 lb/MMBTU fired. The Colorado particulates standard is dependent on the firing rate of the source and varies from 0.2 to 0.3 lb/MMBTU for the upgrading equipment described in Table 9-5-3. The retorts are both fuel burning and solids handling processes. The weight rate emission standard for Phase I retorting allows

Table 9-5-3

PHASE I - STAGE 1 PROCESSING FACILITY ESTIMATED STACK EMISSION DATA

Stack Description	Preheat System	Steam Superheater-Ball Circ.	Shale Moisturizing	Thermal Cracker Preheat	High BTU Gas Plant Reboiler	Steam Superheater and Thermal Oxidizer		
Stack Location No.	1	2	3	16	17	18	19	Combined(1)
Stack Height, ft.	310	310	310	80	150	-	-	100
Stack Diameter, ft.	10.0	5.5	3.0	3.5	2.0	-	-	4.0
Stack Gas Parameters								
Gas Flow								
lb/hr	436,000	115,000	68,600	32,500	7,300	21,500	34,700	56,200
ACFM	145,700	42,300	35,100	21,400	4,700	16,100	11,700	27,300
Molecular Weight	27.5	25.7	20.0	28.5	28.5	28.5	27.5	27.9
Exit Temperature, °F	125	140	191	735	700	900	130	400
Moisture Content, Vol %	17	33	83	13	13	13	20	17
SO_2 Content								
lb/hr	7.6	1.4	-	1.1	0.2	0.7	2.6	3.3
ppm(vol)	7	5	-	15	15	15	32	25
lb/MMBTU fired	0.027	0.167	-	0.032	0.026	0.032	0.144	0.083
NO_x Content								
lb/hr	80	15	-	11	2.5	7.4	48	55.5
ppm (vol)	110	71	-	210	210	210	820	590
lb/MMBTU fired	0.289	1.785	-	0.323	0.329	0.336	2.667	1.387
Particulates								
lb/hr	31	38	36	0.6	0.13	0.4	1.4	1.8
grains/ACF	0.025	0.106	0.12	0.003	0.0032	0.0028	0.014	0.0077
Hydrocarbons								
lb/hr	35	5	-	0.9	0.2	0.6	0.4	1.0
Firing Duty, MMBTU/hr	277	8.4	-	34	7.6	22	18	40

(1) Flue gas from thermal oxidizer flows to steam superheater stack.

45.9 lb/hr from each TOSCO stack. Table 9-5-3 shows ompliance with this standard. Colorado Regulation 1 also limits SO_2 stack concentrations to 500 ppm for sources under 5 tons/day. Table 9-5-3 shows all sources to be within this standard.

Colorado Regulation 6 limits fuel gas hydrogen sulfide concentrations to 150 ppmv. Phase I fuel gas will contain 100 ppmv of hydrogen sulfide. Hydrocarbon emissions from storage tanks in the Phase I processing facility are controlled by using floating roof tanks where appropriate for the more volatile liquids. Estimates of Phase I - Stage 1 storage tanks emissions are given in Table 9-5-4. Stage 2 conditions were modeled so that emission rates used in the dispersion model are double the Stage 1 estimates.

2. Operation and Maintenance - The following basic guidelines will be used for operation and maintenance of the air quality control systems in the processing facility:

- Detailed operating manuals will be prepared giving proper procedures for startup, operation, and shutdown of equipment. Operators will receive basic and on-the-job instruction in these procedures.
- Instrumentation required for process control and measurement, such as temperature, pressure, and flow rate indicators, recorders, and controllers will be provided. Analytical equipment will be available for periodic measurement of the flow and composition of stack gases.
- Periodic inspection and maintenance of equipment and instrumentation will be scheduled to insure proper performance of the systems in accordance with design.

B. Phase II

1. Plant Design - The design philosophy with regard to air quality control is essentially the same as that used for the Phase I facility. Higher capacity and increased complexity of Phase II processing, however, requires more extensive use of control systems. The concept of supplying plant fuel requirements with purified gas was retained by treating high BTU gas from

Table 9-5-4

PHASE I - STAGE 1 PROCESSING FACILITY ESTIMATED TANK VAPOR LOSSES

Tank Description	Fuel Oil Storage	Product Oil Storage	Heavy Oil Storage	Thermal Cracker Feed Storage	Naphtha Storage
Tank Service	Diesel Oil	Product Shale Oil	Residue	Gas Oil	Naphtha
Tank Data					
Number	1	2	1	1	1
Dimensions, ft	60 Øx42	100 Øx36	60 Øx42	60 Øx42	20 Øx18
Capacity, BBL each	20,000	50,000	20,000	20,000	1,000
Type	Cone Roof	Floating Roof	Cone Roof	Cone Roof	Floating Roof
Storage Temp °F	100	55	600	400	100
Avg. Outage, %	50	50	50	50	50
Annual Turnovers	5	50	10	12	5
Vapor Pressure of Contents, psia	0.1	max. 2.5	0.1	0.5	5.5
Tank Vapor Losses, BBL/yr					
Each	42.0	max. 551	36.9	162.6	24.6
Total	42.0	max.170.2	36.9	162.6	24.6

TOSCO II retorts and low BTU gas from Gas Combustion retorts in amine and ammoniacal liquor scrubbing systems. Removal of sulfur compounds from both gases is about 98%; ammonia removal is about 99%. Purified high BTU gas and C_4s are used as fuel for process heaters and boilers; a mixture of purified high BTU and low BTU gas is used as fuel for the TOSCO II retorts.

The important process stacks in the Phase II processing facility are located in the retorting, sulfur recovery and hydrogen plants. Flue gases from the TOSCO II retorting plant are treated as described for the Phase I facility. Vapors from the shale moisturizing system in the gas combustion retorting plant are passed through a high energy venturi scrubber to remove entrained shale dust.

Water recovered from the raw oil recovery, delayed coking, hydrogen, hydrotreating, and gas plants is sent to the ammonia recovery plant. Dissolved hydrogen sulfide and ammonia are removed from the water and the ammonia is recovered as a liquid by-product. Hydrogen sulfide containing gases from the ammonia recovery and hydrogen plants are sent to the sulfur recovery plant where about 99.5% of the contained sulfur is removed and converted to elemental sulfur by-product.

Carbon dioxide produced as a by-product in the hydrogen plant is vented to the atmosphere. The carbon dioxide stream is scrubbed prior to venting to reduce the total contained sulfur compounds to a level of about 5 ppm hydrogen sulfide and 20 ppm carbonyl sulfide. Estimated Phase II processing facility emissions are presented in Table 9-5-5.

Table 9-5-5 shows, as in Phase I compliance with all Colorado particulates and SO_2 emissions standards. The approximate hydrogen sulfide concentrations in the Phase II fuel gases are 140 ppmv for the low BTU gas and 100 ppmv for the high BTU fuel. The limit imposed by Colorado Regulation 6 is 150 ppmv of hydrogen sulfide.

Emissions of particulates and nitrogen oxides from the utility boilers are limited by Colorado's Regulation 6 and EPA New Source Performance Standards. The particulates standard is 0.1 lb/MMBTU and nitrogen oxides are limited to 0.2 lb/MMBTU. Table 9-5-5 shows compliance.

Table 9-5-5

PHASE II - PROCESSING FACILITY ESTIMATED STACK EMISSION DATA

Stack Description	TOSCO II Preheat System	TOSCO II Steam Superheater Ball Circulation	TOSCO II Shale Moisturizing	GCR Air Preheater	GCR Shale Moisturizer Scrubber	Coker Feed Heater	Coke Cooler Vent to Flare	Gas Oil Hydrotreater Heaters
No. of Stacks	7	7	7	2	2	1	1	1
Stack Location No.	1	2	3	4	5	14	12	8
Stack Height, ft.	460	460	460	175	175	120	150	70
Stack Diameter, ft.	11.0	5.5	3.0	5.0	0.5	4.5	1.5	6.0
Stack Gas Parameters								
Gas Flow								
lb/hr	3,623,900	827,750	480,200	84,900	1,920	57,900	12,000(1)	110,800
ACFM	1,197,000	304,500	243,600	74,000	710	36,600	21,000	66,900
Molecular Weight	28.03	26.0	20.1	28.1	25.6	28.1	2.9	28.1
Exit Temperature	127	146	187	1,100	140	670	2,700	620
Moisture Content, Vol %	18	34	83	14.6	31	14.6	16	14.6
SO_2 Content								
lb/hr	217	33	-	1.4	-	1.0	3	1.9
ppm (vol)	26	15	-	7.6	-	7.6	-	7.6
lb/MMBTU fired	0.097	0.270	-	0.016	-	0.016	0.231	0.016
NO_x Content								
lb/hr	581	123	-	28	-	19	-	37
ppm (vol)	98	84	-	200	-	200	-	200
lb/MMBTU fired	0.262	1.008	-	0.315	-	0.311	-	0.319
Particulates								
lb/hr	238	133	70	1.7	0.7	1.2	-	2.3
grains/ACF	0.023	0.051	0.034	0.005	0.11	0.004	-	0.004
Hydrocarbons								
lb/hr	287	34	-	2.6	-	1.8	-	3.4
Firing Duty, MMBTU/hr	2219	122	-	89	-	61	13(1)	116

(1) Maximum flow-occurs only for 15 minutes/day

Stack Description	Gas Oil Hydrotreater Fired Boiler	Naphtha Hydrotreater Heaters	Hydrogen Plant Carbon Dioxide	Glycol Fired Reboiler	Sulfur Plant Tailgas	Utility Boilers
No. of Stacks	1	1	1	1	1	1
Stack Location No.	9	13	11	6	7	15
Stack Height, ft.	70	60	70	175	45	120
Stack Diameter, ft.	6.0	3.5	3.5	5.5	2.5	12
Stack Gas Parameters						
Gas Flow						
lb/hr	100,000	29,500	308,000	90,600	101,200	549,500
ACFM	61,000	23,000	64,400	54,200	28,300	334,900
Molecular Weight	28.1	28.1	41.24	28.1	33.2	28.3
Exit Temperature	620	940	86	610	130	635
Moisture Content, Vol %		14.6	0	14.6	21	14.7
SO_2 Content						
lb/hr	1.8	0.5	12	1.6	40	6.6
ppm (vol)	7.6	7.6	25(3)	7.6	200(2)	5.3
lb/MMBTU fired	0.017	0.016	-	0.017	-	0.010
NO_x Content						
lb/hr	34	10	-	30	-	130
ppm (vol)	200	200	-	200	-	150
lb/MMBTU fired	0.321	0.323	-	0.316	-	0.199
Particulates						
lb/hr	2.1	0.6	-	1.9	-	12
grains/ACF	0.004	0.003	-	0.004	-	0.004
Hydrocarbons						
lb/hr	3.1	0.9	-	2.8	-	12
Firing Duty, MMBTU/hr	106	31	-	95	-	654

(2) Total sulfur compounds as SO_2: CS_2 = 64, COS = 64, H_2S = 8 PPMV

(3) Total sulfur compounds as SO_2: COS = 20, H_2S = 5 PPMV

Hydrocarbon emissions from storage tanks in the Phase II processing facilities are controlled by using floating roof tanks where appropriate for the more volatile liquids. Estimates of storage tank emissions are given in Table 9-5-6.

2. Operation and Maintenance - The basic guidelines established in Phase I for the operation and maintenance of air quality control systems will be followed in Phase II. Operating manuals will be prepared and operator training will be carried out for control systems not previously used in Phase I.

5.5 PROCESSED SHALE AND OVERBURDEN DISPOSAL

The processed shale, overburden and sub-ore will be deposited as described in Section 7. As the processed shale disposal pile reaches its crest, it will be covered with overburden and topsoil and then revegetated. The methods of transporting and handling will be somewhat different for Phase I and Phase II, but the dust control techniques will be essentially the same. No data is presently available for predicting accurately particulate emissions from the processed shale and overburden disposal operations. However, planned control methods described below are believed adequate; in addition, a monitoring site will be set up near the disposal area to verify the effectiveness of these control methods.

A. Phase I - Large (150-ton) bottom dump haul trucks or rubber-tired scrapers will be used to transport processed shale from the processing facility to the disposal area. The trucks, which will be loaded from a processed shale storage bin, will haul the processed shale to the disposal area where it will be dumped, spread and compacted to form a stable disposal pile. Water will be added, as required, by sprinkling or using a water truck.

The amount of dust generated by the processed shale handling will be very dependent on the moisture content. It is planned that the processed shale will be kept at a moisture content of 11% to 19%, therefore little dust is expected during handling, and compaction.

Table 9-5-6

PHASE II PROCESSING FACILITY ESTIMATED TANK VAPOR LOSSES

Tank Description	Product Naphtha Storage	Product Gas Oil Storage	Product Diesel Storage	Raw Shale Oil Storage	Residue Storage
Tank Service	Hydro-treated Naphtha	Hydro-treated Gas Oil	Diesel Oil	Raw GCR Oil	Raw Shale Oil Residue
Tank Data					
Number	1	2	1	1	1
Dimensions, FT	100 Ø x 54	100 Ø x 56	35 Ø x 58	120 Ø x 56	102 Ø x 56
Capacity, BBL	75500	95000	10000	11300	81500
Type	Floating Roof	Cone Roof	Floating Roof	Floating Roof	Cone Roof
Storage Temp °F	50	100	50	100	300
Avg Outage, %	50	50	50	50	50
Annual Turnovers	55	51	33	59	56
Vapor Pressure of Contents, PSIA	2.2	0.01	0.02	0.01	0.001
Tank Vapor Losses, BBL/yr					
Each	120	29	0.5	2	2
Total	120	58	0.5	2	2

Table 9-5-6 (Continued)

PHASE II PROCESSING FACILITY ESTIMATED TANK VAPOR LOSSES

Tank Description	Raw Naphtha Storage	Raw Gas Oil Storage	Sponge Oil Storage	Hydrogen Plant Feed Tank	Coker Day Tank
Tank Service	Stablizied Naphtha	Raw Gas Oil	Lean Sponge Oil	Shale Oil Residue	Shale Oil Residue
Tank Data					
Number	1	1	1	1	1
Dimensions, FT	110 Ø x 60	163 Ø x 62	90 Ø x 54	18 Ø x 24	30 Ø x 48
Capacity, BBL	101500	190000	61200	1100	6000
Type	Floating Roof	Cone Roof	Cone Roof	Cone Roof	Cone Roof
Storage Temp °F	50	100	50	300	300
Avg Outage, %	50	50	50	50	50
Annual Turnovers	68	66	330	1795	434
Vapor Pressure of Contents, PSI	1.8	0.01	0.02	0.001	0.001
Tank Vapor Losses, BBL/yr					
Each	89	59	56	0.1	0.3
Total	89	59	56	0.1	0.3

Uncompacted processed shale with near zero moisture content is estimated to erode at the rate of 15 inches an hour in a 25 mph wind. When the moisture content is increased to 10%, the processed shale should not begin to erode until the wind speed reaches 35 mph. As the material is compacted and a crust is allowed to form, winds of 60 mph should not cause appreciable erosion.

Dust control measures for the processed shale handling and disposal will consist of maintaining proper moisture content while the material is being hauled, deposited, compacted, shaped and revegetated. Watering with large tank trucks and sprinkling with agricultural type sprinkler systems will control the dust while the processed shale is being placed and revegetated. A natural crust formed by cementing action should keep the processed shale from blowing, if it is not disturbed by mechanical manipulation. Closure of inactive disposal areas from extraneous traffic will prevent the crust from being disturbed. As part of the disposal pile reaches it final height, overburden and soil will be placed over it and revegetation activities will begin.

The overburden material consists almost entirely of rock one inch and larger in size. It is not expected to create much dust during handling and disposal. The large rock will shield the fine material from the wind. The dust control techniques for overburden will be the same as for processed shale. Overburden will be hauled by end-dump trucks and dumped over the edge of the overburden disposal pile.

B. Phase II - The use of haul trucks for transport of processed shale, sub-ore and overburden will be discontinued and conveyors will be installed for Phase II. This change will reduce both dust and exhaust emission from the disposal activities. The conveyors will be covered and hooded. Dust suppression will be used at the transfer points and stacking booms. The same dust control techniques will be used for building the piles as used in Phase I. Maintaining the proper moisture content is the essence of the dust control plan for processed shale, overburden and sub-ore for Phase II.

5.6 SUPPORT FACILITIES

The fugitive dust and particulate emission control techniques for the construction and erection of the support facilities will be similar to those described earlier for the construction of the mine and processing facility. The support facilities will include office buildings, shops, a water control dam, process water reservoir, water, oil and sewage pipelines, electric transmission lines and power distribution facilities. Minimizing land disturbance, frequent watering and prompt revegetation are the key techniques for dust control for both Phase I and Phase II.

5.7 MODELING

Modeling of gaseous pollutants and salt drift was done to estimate potential impacts of the project. Dispersion modeling of various gaseous pollutants was used to aid in the development of an engineering design which will meet ambient air quality standards. The dispersion model calculations were based on inversion intensities and depths describing worst case conditions. In addition, fumigation conditions were simulated to ensure that they did not cause worst case short-term air quality impacts. Deposition of salt resulting from the cooling tower drift was modeled to provide information for assessment of the effects of salt drift on local biota.

A. Dispersion Modeling - Dispersion modeling studies were done to verify that use of best available technology will meet Federal and State ambient air quality standards. The physical processes influencing the dispersion potential of the atmosphere over Tract C-a are discussed below. Applicable ambient air quality standards (legally enforceable concentration limits) are presented to enable interpretation and evaluation of project activities using the modeling results. Estimates of project emission sources modeled were summarized previously in this chapter. The actual dispersion modeling methodology, along with a discussion of its accuracy and applicability, is presented. Finally, actual modeling results and interpretations are described. In order to preserve a margin of safety in the analyses, conservative estimates were favored in developing the model. As a result adverse environmental impacts will tend to be overstated.

1. Meteorological, Climatological, and Terrain Factors Affecting Air Pollution - Interrelations between topographic features and meteorological conditions influence the transport and dispersion of atmospheric pollutants. These factors, in conjunction with the orientation, position, and character-

tics of the emission sources, govern the air quality impact of the proposed facility. This section describes the meteorological parameters which determine the diffusion capability of the atmosphere in the vicinity of Tract C-a.

The first full year of lower air baseline measurements and analysis were used as the modeling data base. A more complete description of this program is found in Section 3, Chapter 6. Model calculations based upon inversion frequencies and depths (mixing layer data) were made using the data acquired from the seasonal upper air studies which are also discussed more completely in Section 3, Chapter 6. Actual on-site data were used for all modeling calculations.

Wind speed and direction vary with height. Thus, the combined surface and upper air wind field data are critical meteorological information for determining source emission transport. The actual surface flow is dependent upon the terrain in the immediate vicinity of the measurement location. An example of the diversity of surface flow in the Piceance Creek basin is illustrated in Figures 3-6-4 through 3-6-9. Surface wind flow determines the transport for ground and low level source emissions (e.g., dust from crusher bag houses). The upper air wind flow, which is relatively independent of local topography, governs the transport of emissions from elevated sources. Because the majority of the proposed emission sources fall into this elevated source category, the modeling was performed primarily using wind data from the 60-m level of the meteorological tower at Site 1 (see Section 3, Chapter 6) rather than data from nearer the surface.

Emissions are diluted by natural mixing processes in the atmosphere. The initial rate of dilution of source emissions is largely determined by the magnitude of the wind speed at the point where the effluent is released. As wind speeds increase, the emissions are mixed into a larger volume of air per unit time. This mixing is augmented by a combination of complex temperature-dependent horizontal and vertical air motions which disperse the emissions in a direction perpendicular to that of the net transport.

The surface flows within the Piceance Creek basin are governed by local conditions more than by macroscale processes (Nelson, 1975). The specific air movements produced by local conditions are often different than those expected from the major gradient flow. In general, there is a tendency for the surface wind speeds to be lowest about dawn, at which time there is little vertical thermal mixing, and the lower surface air does not couple with the more freely moving upper air. Conversely, velocities of local winds are greatest between 1300 and 1400 hours local time when the air exhibits its greatest tendency to move vertically due to terrestrial heating and couples with the faster air moving above it. During warm afternoons, the laterally constricted but vertically expanded air within valleys tends to blow up the valley axes. This flow develops simultaneously with anabatic (upslope) winds resulting from a greater heating of the valley sides with respect to the valley floors. At night, there is a reverse process, as the colder, denser air at higher elevations drains into the terrain depressions. These downward movements of cold air produce a nocturnal accumulation of cold, dense, stable air at the valley bottoms. The plant site location has been selected on the upper levels of a ridge to avoid air quality problems that could result from this type of drainage flow. Air temperature structure (lapse rate, or the change in air temperature with height above ground) is closely interrelated to the wind flows and, thus, to the extent and type of dispersive characteristics. Within the lower atmosphere, the vertical temperature structure experiences considerable diurnal and annual changes. This is more apparent within the valleys than atop the ridges (See Section 3, Chapter 6).

Inversions generally result from either mechanical or thermal activity. Thermally induced inversions result from radiational and contact cooling at the surface and form frequently over the tract (Nelson, 1975). Stable air masses form within the valley portions of the tract almost every night except during periods of precipitation. Inversions which extend above the ridge levels higher than the plant site are less intense and less frequent. Emissions released within these deep stable layers become trapped and experience horizontal spread. In most cases measured on tract, conditions associated with deep inversions were also associated with moderate upper level winds from the WSW. Plumes trapped in such stable layers remain at the same absolute level as their point of release. The surface elevation drops off steadily northeast of the plant site, and increases to the west. These inversion conditions should only pose an ambient air ground concentration pollution problem for easterly flows. The frequency of occurrence of these stable conditions along with associated mixing layer heights and intensities are presented in Section 3, Chapter 6.

Stability classifications of the atmosphere indicate the potential ability of the air to diffuse pollutants both laterally and vertically. The more unstable an air mass, the more rapidly emissions can be mixed and diluted within it. There are several widely differing techniques for the estimation of the atmospheric stability. These include the measurement of the temperature lapse rate within the first 100 m of the surface, the measurement of the variability of the horizontal and vertical components of the wind direction, and the concurrent measurement of the wind speed and solar insolation. These three techniques and respective definitions of stability categories for each are given in Tables 9-5-7 through 9-5-9. A discussion of the relationship between these categorization schemes and a presentation of their comparative results, can be found in Section 3, Chapter 6. For annual frequencies of occurrence of stability, the vertical temperature gradient classification scheme was employed in modeling analysis. This approach will tend to give more conservative predicted values of ground-level concentrations (Slade, 1968).

Stable conditions are not necessarily those which produce the highest concentrations of pollutants in the atmosphere. Although dry, high-insolation, windy days are associated with unstable conditions, they also produce high natural particulate loading. These conditions are common on and around the tract. The five days with highest concentration of particulates at the four baseline monitoring sites are given in Table 9-5-10. In all cases, these days were associated with an E or D stability using the vertical temperature gradient classification technique, C or D stability

Table 9-5-7

STABILITY DETERMINED FROM TEMPERATURE GRADIENT WITH HEIGHT

Stability Class	Temperature Gradient ($^oC/100m$)
A Extremely unstable	$\Delta T \leqq -1.9$
B Unstable	$-1.9 < \Delta T \leqq -1.7$
C Mod. unstable	$-1.7 < \Delta T \leqq -1.5$
D Neutral	$-1.5 < \Delta T \leqq -0.5$
E Mod. stable	$-0.5 < \Delta T \leqq 1.5$
F Stable	$1.5 < \Delta T$

Source: Slade, 1968

Table 9-5-8

STABILITY DETERMINED FROM WIND SIGMA

Stability Class	Wind Sigma (Degrees)
A	$22.5 \leqq \sigma$
B	$17.5 \leqq \sigma < 22.5$
C	$12.5 \leqq \sigma < 17.5$
D	$7.5 \leqq \sigma < 12.5$
E	$3.75 \leqq \sigma < 7.5$
F	$\sigma < 3.75$

Source: Slade, 1968

Table 9-5-9

STABILITY DETERMINED FROM WIND SPEED AND SOLAR INSOLATION

Wind Speed (mph)	Day (Incoming Solar Radiation)			Night Thin overcast or	
	Strong	Moderate	Slight	$\geqq 4/8$ cloud cover	$\leqq 3/8$ cloud cover
<4	A	A-B	B		
4-7	A-B	B	C	E	F
7-11	B	B-C	C	D	E
11-13	C	C-D	D	D	D
>13	C	D	D	D	D

Source: Slade, 1968

Table 9-5-10

FIVE DAYS OF HIGHEST PARTICULATE CONCENTRATIONS DURING BASELINE PROGRAMS AT THE FOUR MONITORING SITES AT TRACT C-a

Date	Concentration (g/m^3)	Average Wind Speed (mph)	Maximum Wind Speed During Day	Average Wind Speed at Site 1 (mph)	Average Relative Humidity (percent)	Stability By Average Temperature Gradient	Stability By Average Wind Sigma	Stability By Wind Speed/ Insolation
				SITE 1				
July 3	211.8	5.62	10.8	5.62	19.3	D	C	D
July 5	207.4	5.66	9.7	5.66	26.1	D	C	D
May 4	95.3	16.40	29.6	16.40	25.7	E	*	D
June 18	90.3	8.94	16.8	8.94	60.0	D	C	D
April 25	81.9	18.13	26.4	18.13	25.1	E	*	D
				SITE 2				
October 7	101.7	18.32	30.6	14.73	36.0	D	C	D
June 24	95.4	11.33	21.1	9.27	17.5	E	D	D
May 4	84.2	20.26	29.4	16.40	25.7	E	*	D
October 22	65.7	15.35	27.1	12.63	40.8	D	C	D
July 3	63.4	7.11	14.6	5.62	19.3	D	C	D
				SITE 3				
August 17	247.0	7.70	12.0	9.25	16.2	E	D	D
October 25	232.5	4.84	9.0	5.98	37.1	E	C	D
April 25	163.1	13.39	21.2	18.13	25.1	E	*	D
October 7	136.6	9.87	20.4	14.73	36.0	D	C	D
August 2	136.5	7.28	13.0	7.82	16.1	E	D	D
				SITE 4				
October 7	469.3	11.51	27.3	14.73	36.0	D	C	D
June 24	140.8	8.29	18.0	9.27	17.5	E	D	D
June 27	123.7	10.60	23.6	9.72	16.5	E	C	D
June 18	120.4	7.33	20.6	8.94	60.0	D	C	D
April 25	111.2	15.76	27.2	18.13	25.1	E	*	D

* Monitoring of the wind direction deviation (SIGMA) did not begin until June 1, 1975.

using the wind direction deviation classification technique, and D stability using the wind speed/insolation technique to determine the atmospheric stability. Windy, neutral conditions (D stability) tend to produce the highest natural particulate loading. However, these conditions are often associated with precipitation which results in lower background concentrations due to higher humidity and particulate scavenging.

2. Air Quality Standards and Classifications - The following discussion summarizes the ambient air quality regulations used for evaluating and interpreting the modeling results. More complete presentations of this information can be found in Section 3, Chapter 5 and subsection 8 of this chapter.

a. Colorado State Standards - Colorado has adopted air pollution control regulations that promulgate both air quality standards and emission regulations equaling or exceeding the stringency of the National Ambient Air Quality Standards. For application of these regulations, the State of Colorado is divided into three Air Quality Category Regions. The Piceance Creek basin is currently classified as Category I. The ambient standards are presented in Table 9-5-11. A responsibility of the Colorado Department of Health, Air Pollution Control Division is to ensure that the State standards are attained and kept.

Table 9-5-11

STATE OF COLORADO AMBIENT AIR QUALITY STANDARDS

Emission	Averaging Time	Maximum Allowable Increments over Baseline ($\mu g/m^3$)		
		Category I	Category II	Category III
SO_2	Annual	3	15	60
	24-hour max	15	100	260
	3-hour max	75	700	1300
		Maximum allowable ambient air concentrations		
Particulates	Annual	45		
	24-hour max	150		

b. Federal Standards - Two categories of Federal air quality regulations and standards are applicable to the oil shale development. These are presented below.

1) National Ambient Air Quality Standards (NAAQS) - National Ambient Air Quality Standards define the maximum allowable ground level concentrations of pollutants over specified averaging periods. The applicable regulations are itemized in Table 9-5-12.

2) Significant Deterioration Regulations - Federal air quality non-deterioration regulations limit the amount of pollutant which can be added to 1975 "baseline" concentrations. State of Colorado standards for sulfur dioxide (SO_2) are also written in terms of increments over baseline concentrations (see above). There are three area classifications involved in the Federal incremental standards. The Piceance Creek basin is subject to Class II regulations. Federal maximum allowable increments to air quality baselines are shown in Table 9-5-13. Class III standards state simply that pollutant levels are not to exceed the National Air Quality Standards.

Table 9-5-13

MAXIMUM ALLOWABLE FEDERAL INCREMENTS FOR AREA CLASSES: SIGNIFICANT DETERIORATION REGULATIONS

Emission	Averaging Time	Class I ($\mu g/m^3$)	Class II ($\mu g/m^3$)
Particulates	Annual*	5	10
	24-hour max	10	30
Sulfur Dioxide	Annual	2	15
	24-hour max	5	100
	3-hour max	25	700

* Geometric Mean

Table 9-5-12

NATIONAL AMBIENT AIR QUALITY STANDARDS

Emission	Averaging Time	Primary Standards (Human Health) ($\mu g/m^3$)	Secondary Standards (Public Welfare) ($\mu g/m^3$)
Sulfur Oxides (SO_2)	Annual	80	None
	24-hour*	365	None
	3-hour*	None	1300
Nitrogen Dioxide (NO_2)	Annual	100	100
Particulates	Annual†	75	60
	24-hour*	260	150
Hydrocarbons (corrected for CH_4)	3-hour* (6-9 am)	160	160
Carbon Monoxide	8-hour*	10,000	10,000
	1-hour*	40,000	40,000
Oxidant (corrected for NO_2, SO_2)	1-hour*	160	160

* Not to be exceeded more than once per year.

† Geometric mean.

3. Source Emission Inventory - The plant configuration is discussed in separate sections of this detailed development plan. A discussion of emission sources for mining, processing, and processed shale and overburden disposal for both Phase I and II development and the controls for each were discussed previously in this section. A map of the location of the various processing sources is shown in Figure 6-5-1. Modeling was performed for two cases, Phase I - Stage 2 and Phase II. The Phase I - Stage 2 operation period was chosen for the modeling because it will have higher emissions rates than Phase I - Stage 1 operations.

The technique of source grouping was applied to some emission sources used in the modeling analysis. In a number of cases project operations have multiple stacks with identical operating parameters; stacks of this type were grouped together. The flow rate, temperature, stack diameter and height of each composite stack were kept the same as each of the separate stacks making up the group. The source release rate from each group, however, was the sum of the emissions from the individual stacks in the group.

The source configurations and associated information used in the modeling analyses are presented in computer generated form shown in Tables 9-5-14 through 9-5-17. On these tables, the SOURCE NAME is an alphanumeric title given to each source or source group for easy distinction. COORDX and COORDY are internal digital representations of the relative positions of each source (center of computer coordinate system is 460,60). STK HT is the physical stack height of the respective source (release height for area sources) in meters above the elevation of the base of the stack. EMISS RATE is the release rate of the respective effluent in grams per second. FIXD DH is only used for area sources and gives the height in meters chosen for the effluent to rise above the release point.

SOR W is the width of an area source in meters (unused for point sources or stack sources). SOR H is the absolute elevation above means sea level in

Table 9-5-14

SO_2 EMISSIONS SOURCES AND ASSOCIATED PARAMETERS USED IN THE MODELING ANALYSIS

PHASE I

```
    SOURCE NAME              COORDX COORDY  STK HT  EMISS RATE   FIXD DH  SOR W  SOR H  BRIGUN  BRIGE  BRIGF  AIR T  GAS T  DIAM  GAS V
1 1A-B SO2 PHASE 1:ST2       469.92  58.54     95.  1.9200E+00*********     0.  7155.   303.    87.    72.   273.   325.   3.1    9.4
2 2A-B SO2 PHASE 1:ST2       469.92  58.30     95.  3.5000E-01*********     0.  7155.   132.    60.    50.   273.   333.   1.7    9.0
3 16   SO2 PHASE 1:ST2       467.31  59.26     24.  2.8000E-01*********     0.  7155.   190.    71.    59.   273.   664.   1.1   11.3
4 18   SO2 PHASE 1:ST2       467.31  60.74     30.  8.3000E-01*********     0.  7155.   206.    73.    61.   273.   554.   1.2   11.0
```

PHASE II

```
    SOURCE NAME              COORDX COORDY  STK HT  EMISS RATE   FIXD DH  SOR W  SOR H  BRIGUN  BRIGE  BRIGF  AIR T  GAS T  DIAM  GAS V
1 1A-G SO2 PHASE2            470.24  58.54    140.  2.7370E+01*********     0.  7155.   345.    92.    77.   273.   326.   3.3    9.1
2 2A-G SO2 PHASE2            470.24  58.29    140.  4.4300E+00*********     0.  7155.   139.    62.    51.   273.   336.   1.7    8.3
3 6  SO2 PHASE2              473.90  55.85     38.  2.0000E-01*********     0.  7205.   362.    94.    78.   273.   594.   1.7   11.6
4 8  SO2 PHASE2              472.20  65.12     38.  2.4000E-01*********     0.  7100.   425.   101.    84.   273.   600.   1.8   12.0
5 9  SO2 PHASE2              472.93  65.10     38.  2.3000E-01*********     0.  7100.   397.    98.    81.   273.   600.   1.8   11.0
6 15 SO2 PHASE2              466.46  61.10     46.  8.3000E-01*********     0.  7125.  1119.   174.   144.   273.   608.   3.7   15.0
```

Table 9-5-15

NO_X EMISSIONS SOURCES AND ASSOCIATED PARAMETERS USED IN THE MODELING ANALYSIS

PHASE I

	SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIGUN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1	1A-B NOX PHASE 1:ST2	469.92	58.54	95.	2.0160E+01	*********	0.	7155.	303.	87.	72.	273.	325.	3.1	9.4
2	2A-B NOX PHASE 1:ST2	469.92	58.30	95.	3.7800E+00	*********	0.	7155.	132.	60.	50.	273.	333.	1.7	9.0
3	16 NOX PHASE 1:ST2	467.31	59.26	24.	2.7700E+00	*********	0.	7155.	190.	71.	59.	273.	664.	1.1	11.3
4	18 NOX PHASE 1:ST2	467.31	60.74	30.	1.3860E+01	*********	0.	7155.	206.	73.	61.	273.	554.	1.2	11.0

PHASE II

	SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIGUN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1	1A-G NOX PHASE2	470.24	58.54	140.	7.3220E+01	*********	0.	7155.	345.	92.	77.	273.	326.	3.3	9.1
2	2A-G NOX PHASE2	470.24	58.29	140.	1.5880E+01	*********	0.	7155.	139.	62.	51.	273.	336.	1.7	9.3
3	4A NOX PHASE2	471.22	55.37	38.	2.0200E+00	*********	0.	7205.	357.	94.	78.	273.	866.	1.5	11.0
4	4B NOX PHASE2	472.93	55.37	38.	1.5100E+00	*********	0.	7205.	357.	94.	78.	273.	866.	1.5	11.0
5	6 NOX PHASE2	473.90	55.85	38.	3.7800E+00	*********	0.	7205.	362.	94.	78.	273.	594.	1.7	11.6
6	8 NOX PHASE2	472.20	65.12	38.	4.6600E+00	*********	0.	7100.	425.	101.	84.	273.	600.	1.8	12.0
7	9 NOX PHASE2	472.93	65.10	38.	4.2800E+00	*********	0.	7100.	397.	98.	81.	273.	600.	1.8	11.0
8	13 NOX PHASE2	471.71	61.95	27.	1.2600E+00	*********	0.	7125.	218.	75.	62.	273.	777.	1.1	12.1
9	14 NOX PHASE2	471.46	61.22	46.	2.3900E+00	*********	0.	7125.	278.	84.	69.	273.	627.	1.4	11.7
10	15 NOX PHASE2	466.46	61.10	46.	1.6380E+01	*********	0.	7125.	1119.	174.	144.	273.	608.	3.7	15.0

Table 9-5-16

NON-METHANE HYDROCARBON EMISSIONS SOURCES AND ASSOCIATED PARAMETERS USED IN THE MODELING ANALYSIS

PHASE I

```
     SOURCE NAME             COORDX COORDY  STK HT  EMISS RATE  FIXD DH  SOR W  SOR H  BRIGUN  BRIGE  BRIGF  AIR T  GAS T  DIAM  GAS V
 1 1A-B THC PHASE 1:ST2      469.92  58.54     95. 8.8200E+00       0.     0.  7155.    303.    67.    72.  273.   325.   3.1   9.4
 2 2A-B THC PHASE 1:ST2      469.92  58.29     95. 1.2600E+00       0.     0.  7155.    132.    60.    50.  273.   333.   1.7   9.0
 3 TANK VAP PHASE 1:ST2      465.84  61.95     15. 4.0700E+00      15.   229.  7155.*********************  273.   273.   0.0   0.0
```

PHASE II

```
     SOURCE NAME             COORDX COORDY  STK HT  EMISS RATE  FIXD DH  SOR W  SOR H  BRIGUN  BRIGE  BRIGF  AIR T  GAS T  DIAM  GAS V
 1 1A-G THC PHASE 2          470.24  58.54    140. 1.5680E+01       0.     0.  7155.    346.    92.    77.  273.   326.   3.3   9.2
 2 2A-G THC PHASE2           470.24  58.29    140. 2.6500E+00       0.     0.  7155.    128.    62.    51.  273.   336.   1.7   8.3
 3 4A  THC PHASE 2           471.22  55.37     38. 1.9000E-01       0.     0.  7205.    397.    98.    81.  273.   866.   1.5  12.6
 4 4B  THC PHASE 2           472.93  55.37     38. 1.4000E-01       0.     0.  7205.    320.    89.    74.  273.   866.   1.5   9.5
 5 14  THC PHASE 2           471.46  61.22     46. 2.3000E-01       0.     0.  7125.    278.    84.    69.  273.   627.   1.4  11.7
 6 8   THC PHASE 2           472.20  65.12     38. 4.3000E-01       0.     0.  7100.    425.   101.    84.  273.   600.   1.8  12.0
 7 9   THC PHASE 2           472.93  65.10     38. 3.9000E-01       0.     0.  7100.    397.    98.    81.  273.   600.   1.8  11.0
 8 6   THC PHASE 2           473.90  55.85     38. 3.5000E-01       0.     0.  7205.    362.    94.    78.  273.   594.   1.7  11.6
 9 15  THC PHASE 2           466.46  61.10     46. 1.5100E+00       0.     0.  7125.   1119.   174.   144.  273.   608.   3.7  15.0
10 TANK VAPHASE2             473.60  66.40     15. 1.5900E+00       0.  1000.  7100.*********************  273.   273.   0.0   0.0
```

Table 9-5-17

PARTICULATES EMISSION SOURCES AND ASSOCIATED PARAMETERS USED IN THE MODELING ANALYSIS

PHASE I

	SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIGUN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1	1A-B PAR PHASE 1:ST2	469.92	58.54	95.	8.5700E+00	*********	0.	7155.	303.	87.	72.	273.	325.	3.1	9.4
2	2A-B PAR PHASE 1:ST2	469.92	58.29	95.	4.7900E+00	*********	0.	7155.	132.	60.	50.	273.	333.	1.7	9.0
3	3A-B PAR PHASE 1:ST2	469.92	58.54	95.	2.5200E+00	*********	0.	7155.	143.	62.	52.	273.	361.	0.9	25.2
4	951 PAR PCRH PH 1	455.12	40.00	37.	2.3000E-01	*********	0.	6912.	25.	28.	24.	273.	289.	0.9	10.7
5	952 PAR PCRHSTO PH 1	468.78	52.69	37.	3.9000E-01	*********	0.	7205.	8.	18.	15.	273.	289.	0.5	10.0
6	954 PAR SECRH1-2PH 1	468.78	54.16	37.	1.7400E+00	*********	0.	7205.	27.	30.	25.	273.	289.	0.9	11.9
7	955 PAR FOST1-2 PH 1	469.02	55.49	37.	3.4000E-01	*********	0.	7205.	9.	15.	12.	273.	289.	0.4	16.4

PHASE II

	SOURCE NAME	COORDX	COORDY	STK HT	EMISS RATE	FIXD DH	SOR W	SOR H	BRIGUN	BRIGE	BRIGF	AIR T	GAS T	DIAM	GAS V
1	1A-G PAR PHASE2	470.24	58.54	140.	2.9990E+01	*********	0.	7155.	345.	92.	77.	273.	326.	3.3	9.1
2	2A-G PAR PHASE2	470.24	58.29	140.	1.8760E+01	*********	0.	7155.	139.	62.	51.	273.	336.	1.7	9.3
3	3A-G PAR PHASE2	470.24	58.54	140.	6.5200E+00	*********	0.	7155.	139.	62.	51.	273.	359.	0.9	24.9
4	6 PAR PHASE2	473.90	55.85	38.	2.4000E-01	*********	0.	7205.	367.	94.	78.	273.	594.	1.7	11.6
5	8 PAR PHASE2	472.20	65.12	38.	2.9000E-01	*********	0.	7100.	425.	101.	84.	273.	600.	1.8	12.0
6	9 PAR PHASE2	472.93	65.10	36.	2.6000E-01	*********	0.	7100.	397.	98.	81.	273.	600.	1.8	11.0
7	15 PAR PHASE2	466.46	61.10	46.	1.5100E+00	*********	0.	7125.	1119.	174.	144.	273.	608.	3.7	15.0
8	9506 PAR PCRHR PH2A	455.12	36.83	9.	8.2000E-01	*********	0.	6950.	25.	28.	24.	273.	289.	0.9	12.0
9	9506 PAR OBCRHR PH2A	455.12	36.03	7.	6.2000E-01	*********	0.	6940.	16.	24.	20.	273.	289.	0.7	10.0
10	9507 PARPCRHSTO PH2A	467.07	52.50	9.	1.7400E+00	9.	0.	7275.	********	********	********	273.	289.	*****	*****
11	9509 PAR2CRH/3TRSC2A	467.31	53.41	37.	3.7000E+00	*********	0.	7275.	45.	37.	31.	273.	289.	1.4	10.2
12	9510 PARTRCRH1-5PH2A	468.05	54.14	37.	4.1800E+00	*********	0.	7275.	35.	33.	28.	273.	289.	1.2	10.3
13	9511 PARFOSTT1-2PH2A	465.76	56.59	37.	3.4000E-01	*********	0.	7275.	3.	12.	10.	273.	289.	0.3	9.0
14	9511 PARFOSTGC1-2 2A	471.22	53.66	37.	4.4000E-01	*********	0.	7275.	3.	12.	10.	273.	289.	0.3	9.0

feet at the base of each source. BRIGUN, BRIGE, and BRIGF are related to the calculated final plume rise heights for unstable, slightly stable, and stable atmospheric conditions respectively. BRIGE and BRIGF are expressed as $\Delta hu^{1/3}$ in $m^{4/3}$ per $sec^{1/3}$ and BRIGUN is expressed as Δhu in m^2 per sec. Δhu is the product of the plume rise height and wind speed. AIR T and GAS T are the ambient air temperature into which the release is made and the temperature of effluent gas in degrees Kelvin, respectively. DIAM is the diameter of the stack (unused for area sources or point sources) at the point of release in meters. GAS V is the effluent flow velocity out of the stack in meters per second (unused for area sources or point sources). Asterisks in a particular entry denote the fact that the calculation was unused in the analysis. The Numeric Prefix to the SOURCE NAME in Tables 9-5-14 through 9-5-17 is indicative of the stack number given in Section 6. For example, 1A-G PAR PHASE 2, 2A-G PAR PHASE 2, and 3A-G PAR PHASE II are the 7 sets of 3 TOSCO II retort stacks; sources 8-14 of Phase II particulate and sources 4-7 of Phase I particulates as shown in Table 9-5-17 are crushing conveging and stockpiling operations sources. Sources 4-6 for Phase II particulates are processing units other than the TOSCO II retorts.

Four major polutants were modeled. These were SO_2, NO_2, particulates, and non-methane hydrocarbons (NMHC). Other substances for which National Ambient Air Quality Standards have been established will not be produced by project operations in sufficient quantity to pose a potential pollution problem.

4. Modeling Methodology - The modeling of air pollution dispersion used is a well established mathematical technique which takes into account physical considerations of the plant orientation and configurations with respect to surrounding terrain features. For this type of dispersion estimate the best attainable accuracy, in the absence of confirming measurements of air quality, is approximately ±15% (Sax, 1974). This accuracy is realized for

near-ideal conditions, that is, continuous emissions, flat ground surface, and steady winds throughout the time period of interest. Best accuracy is obtained for distances between 100 and 2000 m and for averaging intervals in excess of 30 days.

The computer simulation analyses performed to assess the air quality impact of the proposed project was made using two different but related techniques. These were for long-term evaluations (annual periods) and short-term evaluations (3-hr and 24-hr periods). Both the long and short-term evaluations are based on the univariate Gaussian equation. The model used was the EPA Valley model, C8M3D (Burt, 1974) with modifications of the techniques for taking into account mixing layer effects and persistent episodes governing short-term average concentrations.

The following is a more detailed technical description of the modeling techniques. Results of the modeling can be found in subsection E.

a. Long-Term Interval Modeling - The pollutant is assumed to be homogeneously distributed in the horizontal across a 22.5 degree sector. The basic univariate Gaussian equation used is:

$$\chi = \frac{2.03Q}{\sigma_z ux} \exp\left\{ -\tfrac{1}{2} (H/\sigma_z)^2 \right\}$$

for the unlimited mixing case. The symbols used have the meanings given in Turner's "Workbook of Atmospheric Dispersion Estimates" (Turner, 1969). The value of σ_z is determined from the ambient stability category and the distance downwind from the emission using the curves given in "Meteorology and Atomic Energy" (Slade, 1968). To evaluate the time average concentration profiles, predictions based on the above equation (which correspond to "near instantaneous" conditions) were weighted by the joint frequency of occurrence of wind speed, wind direction, and stability on site as measured as part of the baseline monitoring program (Section 3, Chapter 6). Stability was determined using measurements of delta temperature from the

60-m tower (Site 1). In addition, the winds were categorized by direction and speed from data measured at the 60-m level at Site 1 for the long-term averaging analysis.

Because plume rise is dependent upon both stability and wind speed (u) as well as distance downwind (x) (Briggs, 1969), the equation for the concentration (χ) from a single source on a single receptor location is given by the weighting equation:

$$\chi = \frac{2.030}{x} \sum_{n} \sum_{m} \frac{f(\theta,n,m)}{\sigma_z u} \exp\left\{ -\tfrac{1}{2}\left(H/\sigma_z\right)^2 \right\}$$

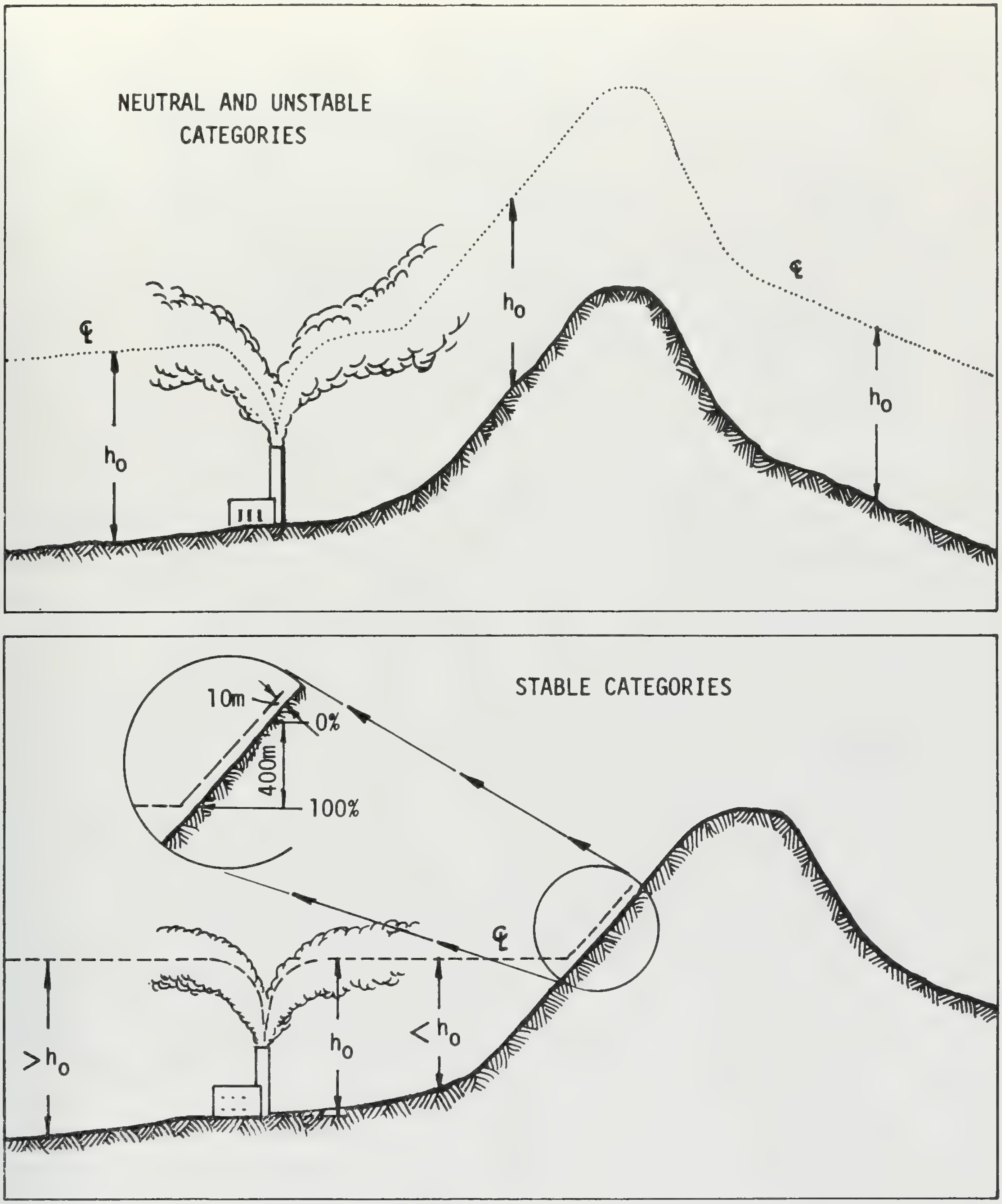
Here f (Θ, n, m) is the frequency of occurrence of winds affecting the receptor, n is the wind speed class, and m is the stability class. Note that σ_z is an implicit function of m, u is an implicit function of n, and H is an implicit function of both m and n. Use of this formulation results in discontinuities in calculated concentrations at wind direction sector boundaries. This is compensated for by using a linear interpolation between sector centerlines. Thus, the concentration at a given receptor location is composed of proportional contributions from both the sector containing the receptor and the nearest adjacent sector. The linear interpolation is done using the factor (c-y)/c where y is the crosswind distance between the receptor and centerline and c is the sector width at the receptor location. Area sources are converted to equivalent virtual point sources. In this conversion, both the downwind distance and source strength are dependent on the particular source-receptor combination similar to the technique used in the Air Quality Display Model (TRW, 1969). Effluent rise above the release point is fixed (plume rise calculations are not performed for area sources).

The terrain in the vicinity of Tract C-a is relatively complex. To take into account the topographic variability in the modeling analysis, the same technique as that used in the EPA Valley Model, C8M3D was incorporated.

The specific method used for handling terrain effects is determined by the atmospheric stability. For stable conditions, the receptor elevation is subtracted from the initial plume centerline height. If the difference is positive (receptor below plume), that difference is used as the plume height for evaluating the concentration at that receptor. A plume with initial height less than 10 m remains at its initial height above ground. If the difference (d) is less than 10 m, it is reset to 10 m for the final calculation after a reduction factor (for the contribution of that source to that receptor for the particular meteorological conditions being evaluated) is computed by (401 + D)/400. Consequently, for $D < 10$m the contribution is reduced linearly with height above the plume along ground level to a value of zero at 400 m above the initial centerline height. However, throughout its climb upward along the terrain, the plume centerline is considered to be 10 m above the surface. Once attaining the top of an obstacle to the flow, the plume is "mathematically" allowed to descend down the lee side of the obstruction. This technique builds added conservatism into the modeling estimates. During neutral or unstable atmospheric conditions, the plume centerline is treated as a constant relative to the terrain (i.e., plume centerlines are not allowed to approach the surface). The two cases discussed above are schematically illustrated in Figure 9-5-1 where ℄ is the plume centerline and h_o is the effective final plume height.

For the air quality impact assessment, topographic elevations were calculated out to a distance of 35 km. Topographic cross sections along the 16 cardinal directions of the terrain data used are presented in Figure 9-5-2. The schematicized central stacks in each plot represent the TOSCO II structures for the Phase II development for comparative purposes. Note the generally higher terrain to the west and the lower terrain to the east.

In all computations made, the program checks for reflection from an elevated inversion base. If appropriate, an interpolation based upon distance from the source was made between the concentrations computed from this and the unlimited mixing case at the same distances. The frequency of occurrence of this elevated inversion base (mixing layer height) is the percentage of days upon which a mixing layer existed. The program takes into account



Source: Burt, 1974

Figure 9-5-1

A SCHEMATIC DESCRIPTION OF THE PLUME HEIGHTS BEHAVIOR ASSUMED IN THE MODEL OVER "ROUGH" TERRAIN FOR UNSTABLE AND STABLE CONDITIONS, RBOSP

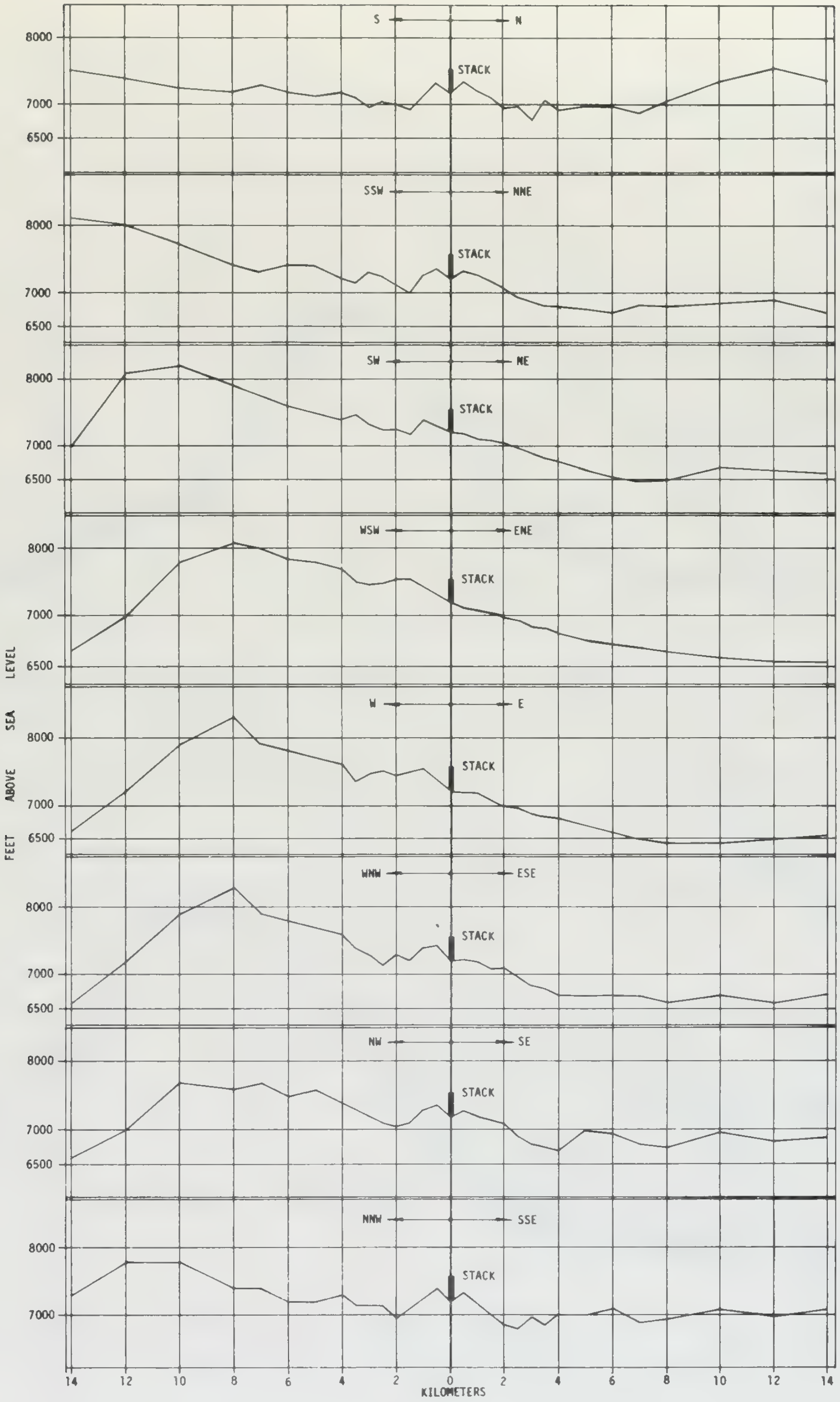


Figure 9-5-2

TOPOGRAPHIC CROSS SECTIONS OF THE AREA AROUND TRACT C-a SHOWING THE TERRAIN ELEVATIONS USED IN THE MODELING SECTION the percentage of days with actual mixing layers; 60% of the time during these days the daytime mixing height is assumed and 40% of the time during these days, the nighttime mixing height is assumed. The average mixing layer heights and their frequency of occurrence were determined from the upper air studies portion of the baseline monitoring program. A summary of the seasonal and annual average statistics of inversions occurring over the tract as measured from the upper air studies and used in the modeling, is shown in Table 3-6-22. Based upon the results of the upper air studies, inversions form over the tract about 34% of the time on an annual basis.

To estimate the rise of the plumes released into the upper level flows, plume rise formulae based upon Brigg's (1969) equations were used. These equations accurately describe the behavior of plumes having temperatures greater than 50°C above the ambient air temperature or volume release rates greater than 50 m^3/sec. All of the process stack effluents of both phases are in this buoyant plume category. The rise of buoyant plumes is determined primarily by stability because of the tendency of the air to augment or oppose their buoyancy. Near the source, the plume rise is in a transition region and is a function of distance downwind. Further from the source, the plume effectively levels off and the final plume rise is constant. Because the formulation of plume rise depends upon the lapse rate for stable atmospheres, there are two estimates of final plume rise for this case (i.e., plume rise with E stability and with F stability). For unstable or neutral conditions there is only one estimate of the final plume rise. These concepts provide the basis for the labels BRIGF, BRIGE, and BRIGUN used in Tables 9-5-14 through 9-5-17.

Although the mining operations stack sources do not lie in the range governed by buoyancy effects (their plume rise is dominated by the initial momentum of the effluent as it leaves the stack), the momentum effect is implicitly included in the evaluation of the buoyancy flux parameter. Estimates of plume rise from mining operation stacks using the Brigg's formulation agree well with estimates made using non-buoyant considerations.

b. Short-Term Interval Modeling - In order to estimate compliance with regulatory standards for short-term averaging intervals (i.e., 3-hr and 24-hr concentrations), the technique described above was modified. The primary assumption used for the short-term model (which also differs from the EPA Valley Model) is that a given meteorological condition persists for a time period as measured during the baseline monitoring program. The hourly concentration along each radial was calculated using the same formulation as described for the long-term technique and then adjusted by the ratio of this persistence duration (for each direction independently) to the averaging interval. The maximum value for the sum for all sources along each radial was chosen as the worst case. Consequently, the isopleth values shown on the figures represent maximum short-term average concentrations which are predicted to occur over the course of the baseline year. They by no means represent the maximum concentrations expected on a single day in the baseline year.

The number of hours of persistence for each radial direction measured at the 60-m level of the Site 1 meteorological tower under all conditions for the 3-hr and 24-hr time periods are shown in Table 9-5-18. (See Section 3, Chapter 6, for a more complete discussion of the persistences measured during the baseline monitoring program). In all cases persistences greater than 10 hours were associated with either E or D stability, as determined from the delta temperature measurement, and winds from 8 to 20 mph. The mixing layer heights as measured by the upper air studies were used to define the highest allowed plume penetrations and were assumed to exist 100% of the time for all short-term interval modeling. The stability classification which provides the maximum concentration due to persistence and frequency of occurrence, as well as small plume rise, is Class E. To provide the most conservatism in the modeling results, the worst case stable conditions were chosen as 4 mph winds under E stability with the above tabulated wind direction persistences. Since the mathematical formulation considered plume impaction effects, these conditions resulted in worst case short-term concentration estimates of SO_2 and non-methane hydrocarbons off site along the ridge making up Cathedral Bluffs immediately

Table 9-5-18

MAXIMUM WIND DIRECTION PERSISTENCE FOR 3-HOUR AND 24-HOUR PERIODS FROM 60-METER LEVEL DATA AT SITE 1

Wind Direction	Persistence (hours)	
	3-hr Period	24-hr period
N	3	8
NNE	3	11
NE	3	8
ENE	3	5
E	3	5
ESE	3	4
SE	2	2
SSE	3	6
S	3	9
SSW	3	16
SW	3	21
WSW	3	15
W	3	12
WNW	3	7
NW	3	8
NNW	3	5

to the west of the proposed facility. Worst case values to the east (lower elevation) occur under unstable conditions with light westerly winds. This is due to the more rapid vertical spread of the plume during these periods in conjunction with the constantly lowering ambient elevation to the east. Although westerly winds occur a much greater percentage of the time, wind speeds associated with these directions tend to be higher (Section 3, Chapter 6) causing greater dilution of pollutants.

As discussed above, the basic univariate Gaussian formulation predicts ground level concentrations on a virtually instantaneous basis (i.e., 3 to 10 minutes). To more realistically estimate the 1-hr average values, the common practice (ASME, 1968; Turner, 1969) is to normalize the estimates, which lowers the values by use of the following relationship:

$$\chi_{1\ \text{hour}} = \chi_t \ (t/60)^r$$

where r takes on different values ranging from 0.17 to 0.41 and t is the averaging time.

Use of this relation results in a reduction of calculated emissions by a factor up to 52%. To further ensure the conservatism of the results of the modeling analysis, the above technique was not used in the computations for any of the averaging intervals, with the exception of the 24-hr average particulate concentration estimates. In this case, the calculated concentrations at each receptor were assumed to be 3 minute averages. For stable conditions, this does not contradict the sector-averaging technique used for the initial calculation. These 3 minute concentrations were then normalized to hourly concentrations using the above technique (multiplication by 0.61, ^{r} = .17) and the hourly values then were adjusted by the ratio of the persistence duration to the averaging interval (3 or 24 hr).

5. Modeling Results - Analytical investigations were done for four horizontal distance ranges, 0-3.5 km, 0-7 km, 0-14 km, and 0-35 km. Computer-generated plots of the predicted air quality impacts of both proposed phases on neighboring regions were made to summarize the modeling analysis results. All possible combinations of pollutants and scales are not

presented here since there is extensive reduncancy among the results for the different scales. Concentration values given in the plots are in micrograms per cubic meter ($\mu g/m^3$) at reference Standard Temperature and Pressure (STP: Standard Temperature = 25^0 Celsius, Standard Pressure = 1013.25 mb).

The impacts of Phase I - Stage 2 operations are presented first, followed by the worst case impact estimates of the calculated effects of operations during Phase II. For all long-term (annual) average plots, joint frequency distribution data between delta temperature and wind speed and wind direction measured at the 60-m level of the Site 1 tower were used as input to the model. The mixing layer frequency of occurrence was taken at 34% with the daytime height at 2,845 ft above the 7,200 ft plant elevation, and the nighttime height at 1,815 ft. These values are averages from the four seasonal upper air studies performed over Tract C-a (Section 3, Chapter 6).

The order in which each of the plots is presented allows direct comparison with the regulatory standards for each pollutant as presented above in Tables 9-5-11, 9-5-12, and 9-5-13. Due to the large number of scales, pollutants, and averaging intervals in the analysis, a cross reference between averaging intervals, distances, parameters, and the corresponding figures is presented in Table 9-5-19.

a. Phase I Operations - The modeling analysis predicts that Phase I - Stage 2 operations will meet present applicable ambient air and significant deterioration standards set by both EPA and the State of Colorado except for the Federal non-methane hydrocarbon standard and the present Colorado Category I 3-hour SO_2 standard. These standards will be met during Phase I - Stage 1 operations. Based on data gathered during Stage 1, an engineering design will be developed for Stage 2 which will result in acceptable non-methane hydrocarbon levels. All Colorado Category II Standards for SO_2 will be met during Phase I - Stage 2 operations.

A summary comparison of modeling results for Phase I - Stage 2 operation with standards is given in Table 9-5-20. A more detailed discussion of the modeling of individual pollutants follows.

1) Sulfur Dioxide - Figures 9-5-3 and 9-5-4 present isopleths of the ground level concentration increments of SO_2 from the Phase I facility

Table 9-5-19

FIGURE NUMBER CROSS REFERENCE FOR VARIOUS PARAMETERS, AVERAGING INTERVALS, AND PLOT SCALES

PHASE I

Parameter	Averaging Interval	Figure Numbers	
		3.5 km Plot Range	14 km Plot Range
SO_2	Annual	9-5-3	9-5-4
	24-hour	9-5-5	9-5-6
	3-hour	9-5-7	9-5-8
NO_2	Annual	9-5-9	9-5-10
Particulates	Annual	9-5-11	9-5-12
	24-hour	9-5-13	9-5-14
Non-Methane Hydrocarbons	3-hour	9-5-15	9-5-16

PHASE II

Parameter	Averaging Interval	Figure Numbers		
		3/5 km Plot Range	14 km Plot Range	35 km Plot Range
SO_2	Annual	9-5-17	9-5-18	9-5-19
	24-hour	9-5-20	9-5-21	-
	3-hour	9-5-22	9-5-23	-
NO_2	Annual	9-5-24	9-5-25	-
Particulates	Annual	9-5-26	9-5-27	9-5-28
	24-hour	9-5-29	9-5-30	-
Non-Methane Hydrocarbons	3-hour	9-5-31	9-5-32	-

Table 9-5-20

COMPARISON OF MODELING RESULTS WITH APPLICABLE STANDARDS FOR PHASE I - STAGE 2 OPERATION

Applicable Standard	Emission	Averaging Time	Standard Limit ($\mu g/m^3$)	Maximum Predicted Off-Site Increment Due to Development ($\mu g/m^3$)	Predicted Off-Site Value ($\mu g/m^3$)
State - Category I					
Max. allowable Increment	SO_2	Annual	3	1	NA
		24-hour	15	14	NA
		3-hour	75	82†	NA
Federal - Class II					
Max. allowable Increment	SO_2	Annual	15	1	NA
		24-hour	100	14	NA
		3-hour	700	82	NA
	Particulates	Annual*	10*	4**	NA
		24-hour	30	22	NA
Colorado Ambient Air Quality Standard	Particulates	Annual	45	4	23
		24-hour	150	22	41
National Ambient Air Quality Standards					
Primary	SO_2	Annual	80	1	10
		24-hour	365	14	23
Secondary	SO_2	3-hour	1300	82	91
Primary	NO_2	Annual	100	14	16
Primary	Particulates	Annual	75	4**	16
		24-hour	260*	22	34
Secondary	"	Annual	60	4**	16
		24-hour	150	22	34
Primary	NMHC	3-hour (6-9 AM)	160	156	221†

* Geometric Mean
** Arithmetic Average
NA - Not Applicable
† See text for clarification

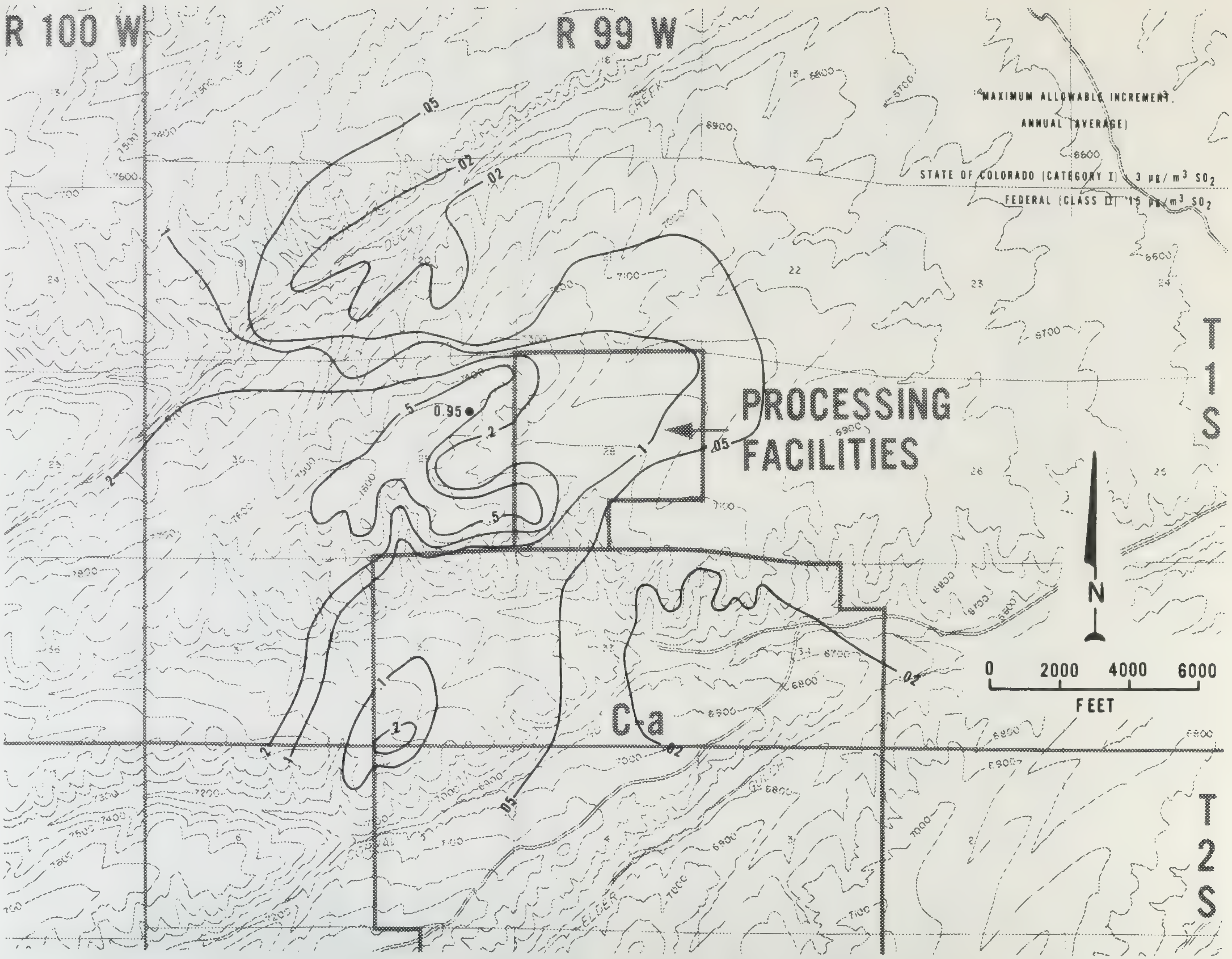


Figure 9-5-3 Phase I, Annual Average SO_2 Concentration Isopleths, µg/m^3, Range 0-3.5 Km.

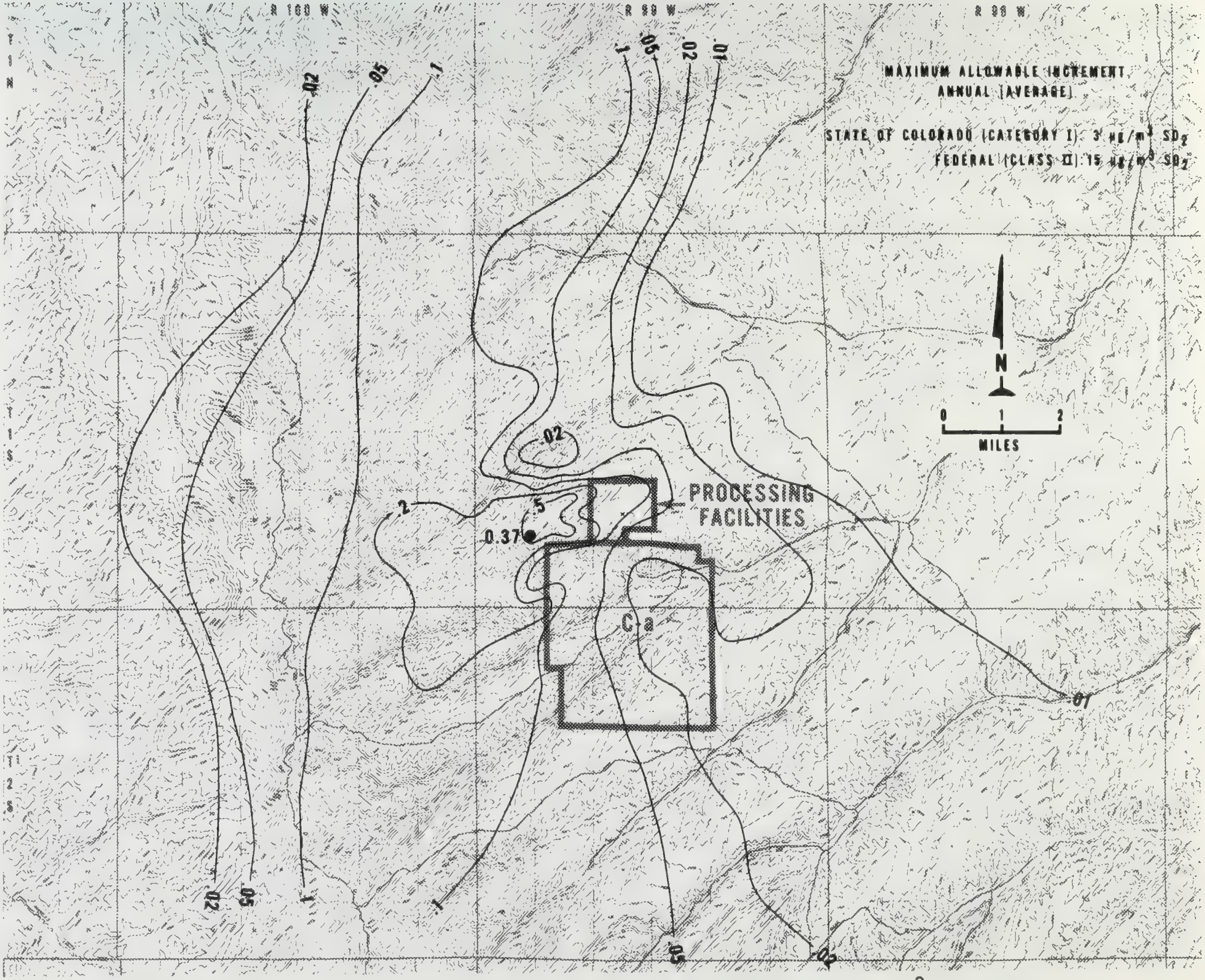

R 100 W
R 99 W
R 98 W
MAXIMUM ALLOWABLE INCREMENT
ANNUAL (AVERAGE)
STATE OF COLORADO (CATEGORY I): 3 μg/m³ SO₂
FEDERAL (CLASS II): 15 μg/m³ SO₂
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
0.37
.5
.2
.1
.05
.02
.01

Figure 9-5-4 Phase I, Annual Average SO_2 Concentration Isopleths, μg/m^3, Range 0-14 Km.

over an annual averaging period. The applicable State of Colorado standard (Table 9-5-11) for the present categorization of the Piceance Creek basin (Category I) is 3 $\mu g/m^3$. The maximum predicted increment of 0.95 $\mu g/m^3$ is well within this regulation. The Federal allowable increment (Table 9-5-13) is 15 $\mu g/m^3$ on an annual average basis. The fact that the point of highest concentration occurs on the prevailing windward side of the tract should be noted. Southwesterly winds occur most often, however, the downwind concentrations produced under these conditions are quite low. Easterly winds, which have a low frequency of occurrence, produce the highest concentration from plume impaction episodes, these being on the Cathedral Bluffs to the west of the tract.

Figures 9-5-5 and 9-5-6 present the worst case 24-hr maximum ground level concentration increments of SO_2 for the Phase I - Stage 2 facility. These values would be expected for the measured direction persistences in conjunction with light winds under E stability. Again note the low concentrations to the east relative to those to the west. The predicted point of maximum 24-hr concentration increment of SO_2 during Phase I operations is on the higher elevations immediately to the southwest of the plant site. This point is within the plant boundary. The highest expected off site 24-hr maximum concentration increment is predicted to occur to the west of the TOSCO II complex and have a value of 10 $\mu g/m^3$. The applicable State of Colorado standard is 15 $\mu g/m^3$. The Federal allowable increment is 100 $\mu g/m^3$ for the 24-hr maximum value (Table 9-5-13).

Figures 9-5-7 and 9-5-8 present the worst case 3-hr maximum ground level concentrations of SO_2 from Phase I operations. The highest off site concentrations again occur to the west of the TOSCO II complex with a 3-hr maximum concentration of 82 $\mu g/m^3$. The appropriate Category I State of Colorado incremental standard is 75 $\mu g/m^3$ (Category II is 700 $\mu g/m^3$) and the Federal 3-hr maximum incremental standard for SO_2 is 700 $\mu g/m^3$ (Table 9-5-13).

2) Nitrogen Dioxide - The annual average expected ground level concentrations of NO_2 from the Phase I - Stage 2 operations are shown in Figures 9-5-9 and 9-5-10. The maximum predicted concentration of approximately 14 $\mu g/m^3$ is due west of the plant site. This maximum concentration is within the National Ambient Air Quality Standards of 100 $\mu g/m^3$ for NO_x (Table 9-5-12).

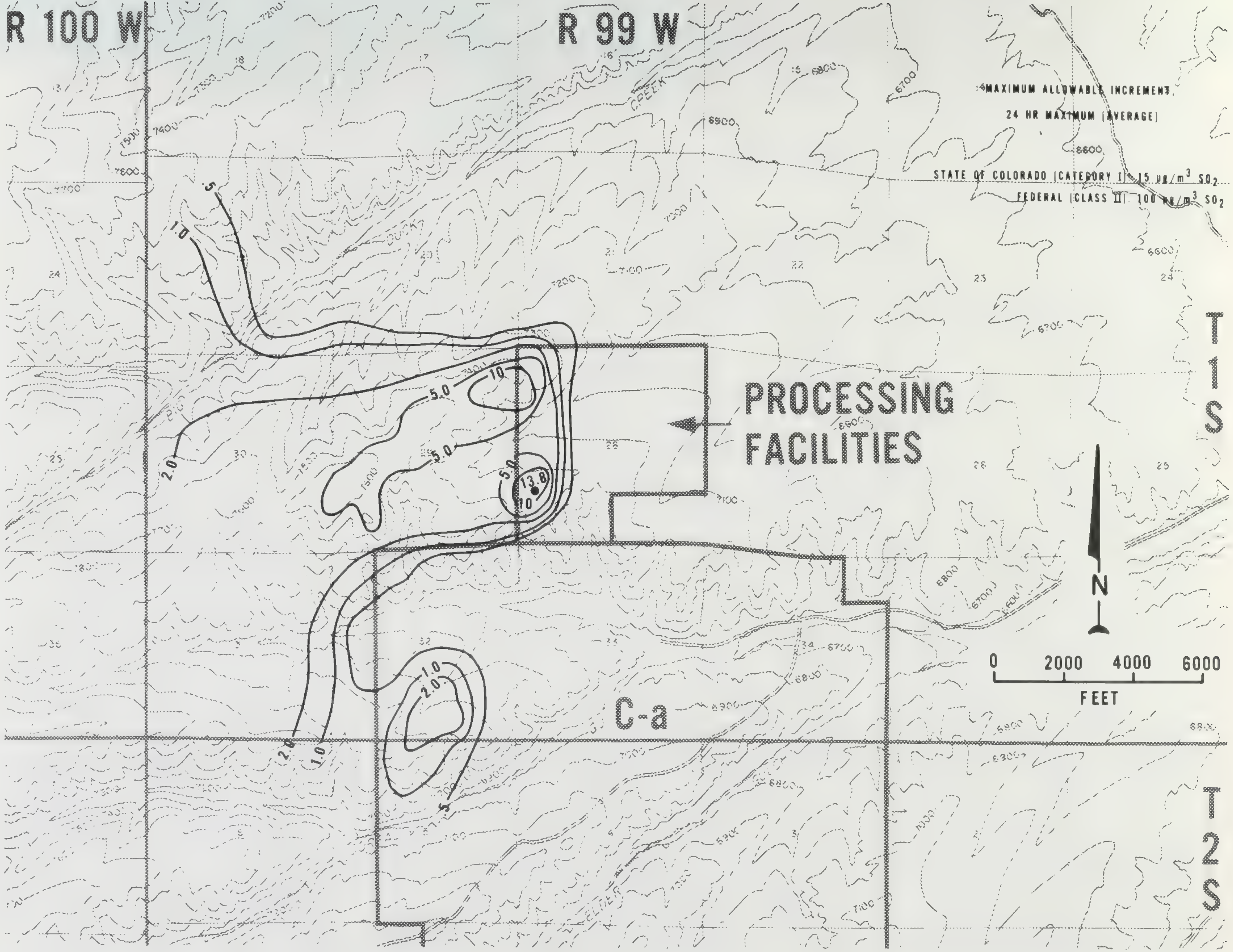


Figure 9-5-5 Phase I, 24 Hr. Maximum Average SO_2 Concentration Isopleths, µg/m³, Range 0-3.5 Km.

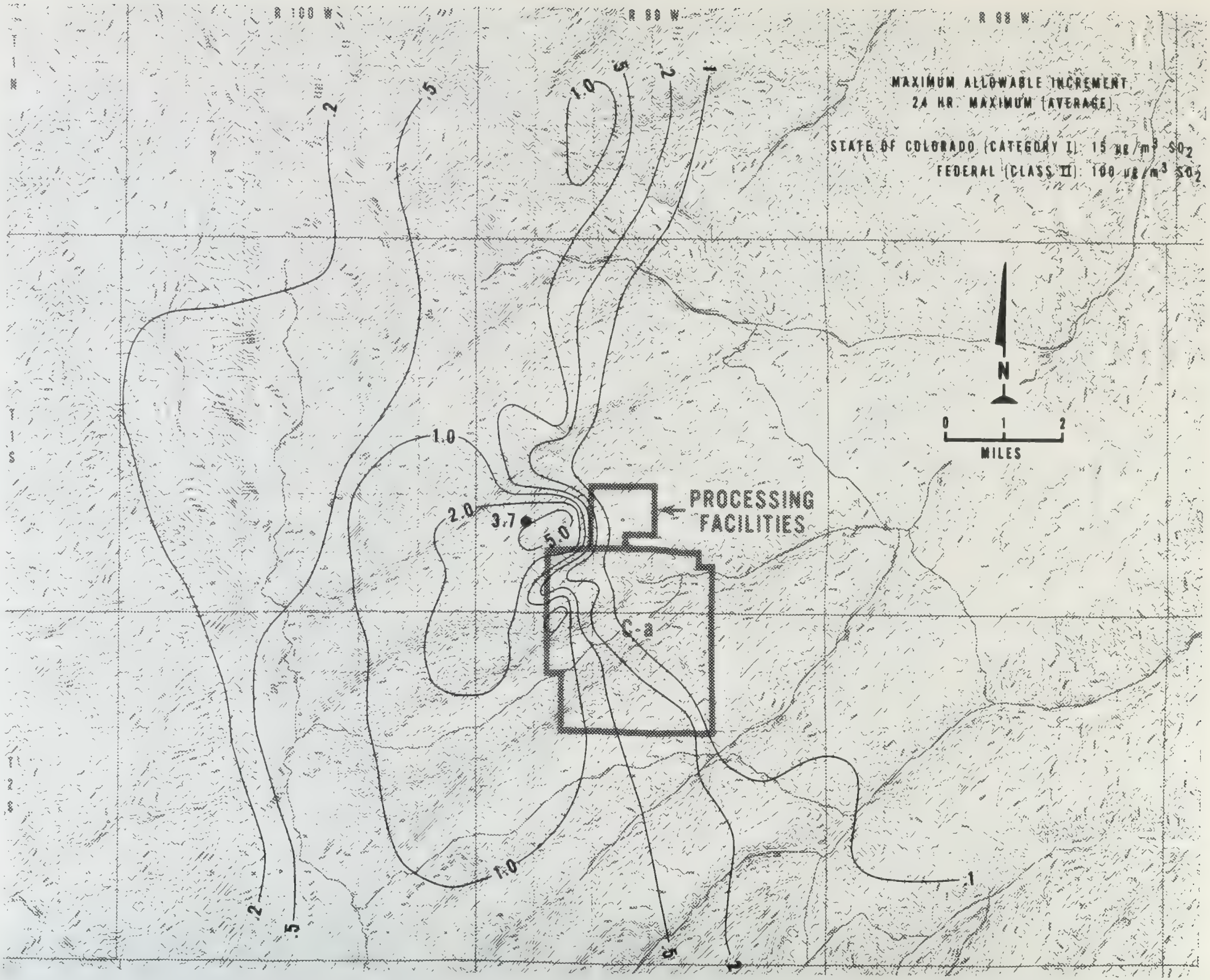

R 100 W
R 99 W
R 98 W
MAXIMUM ALLOWABLE INCREMENT
24 HR. MAXIMUM (AVERAGE)
STATE OF COLORADO (CATEGORY I): 15 μg/m³ SO₂
FEDERAL (CLASS II): 100 μg/m³ SO₂
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
3.7
5.0
2.0
1.0
.5
.2
.1

Figure 9-5-6 Phase I, 24 Hr. Maximum Average SO_2 Concentration Isopleths, $\mu g/m^3$, Range 0-14 KM.

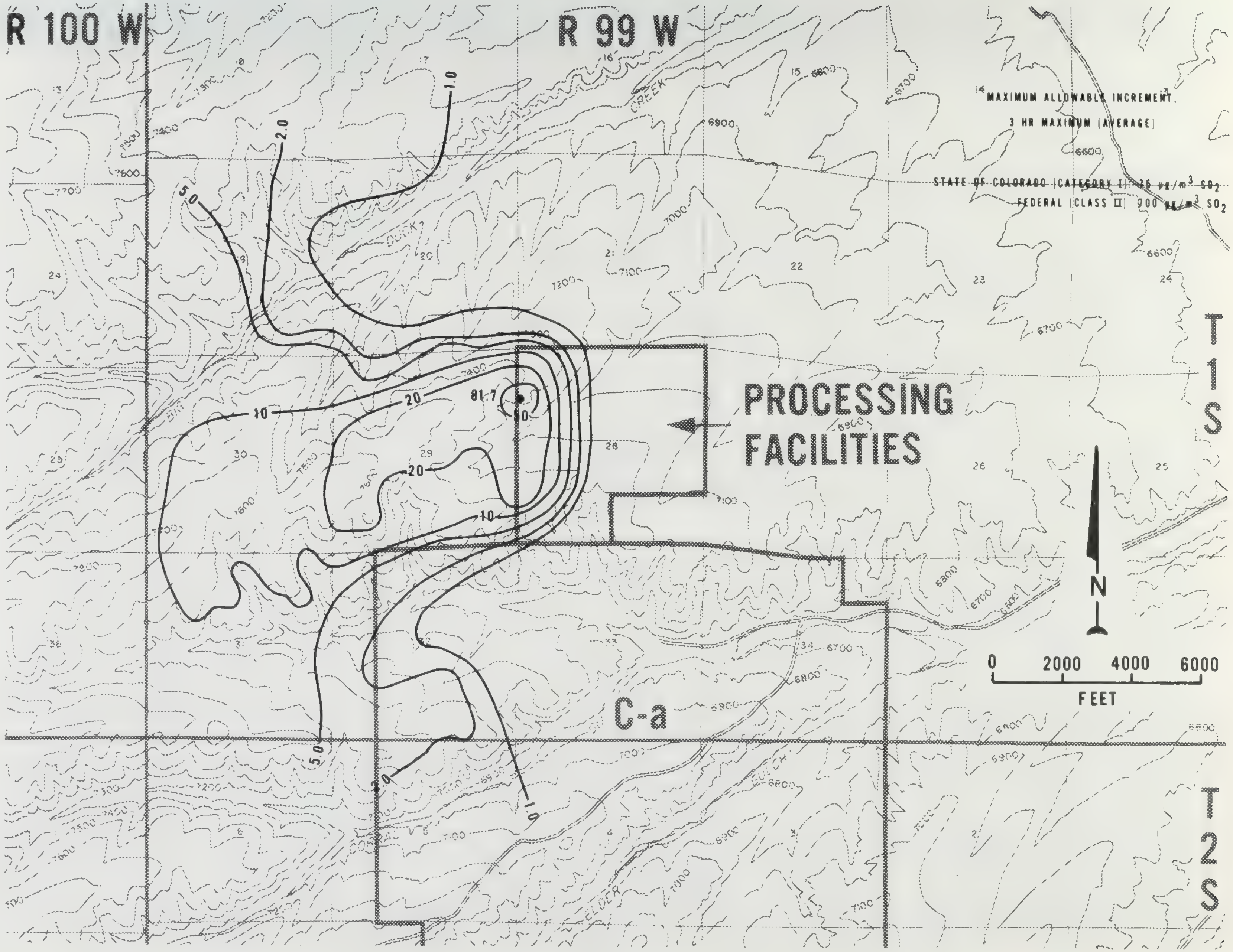


Figure 9-5-7 Phase I, 3 Hr. Maximum Average SO_2 Concentration Isopleths, μg/m³, Range 0-3.5 Km.

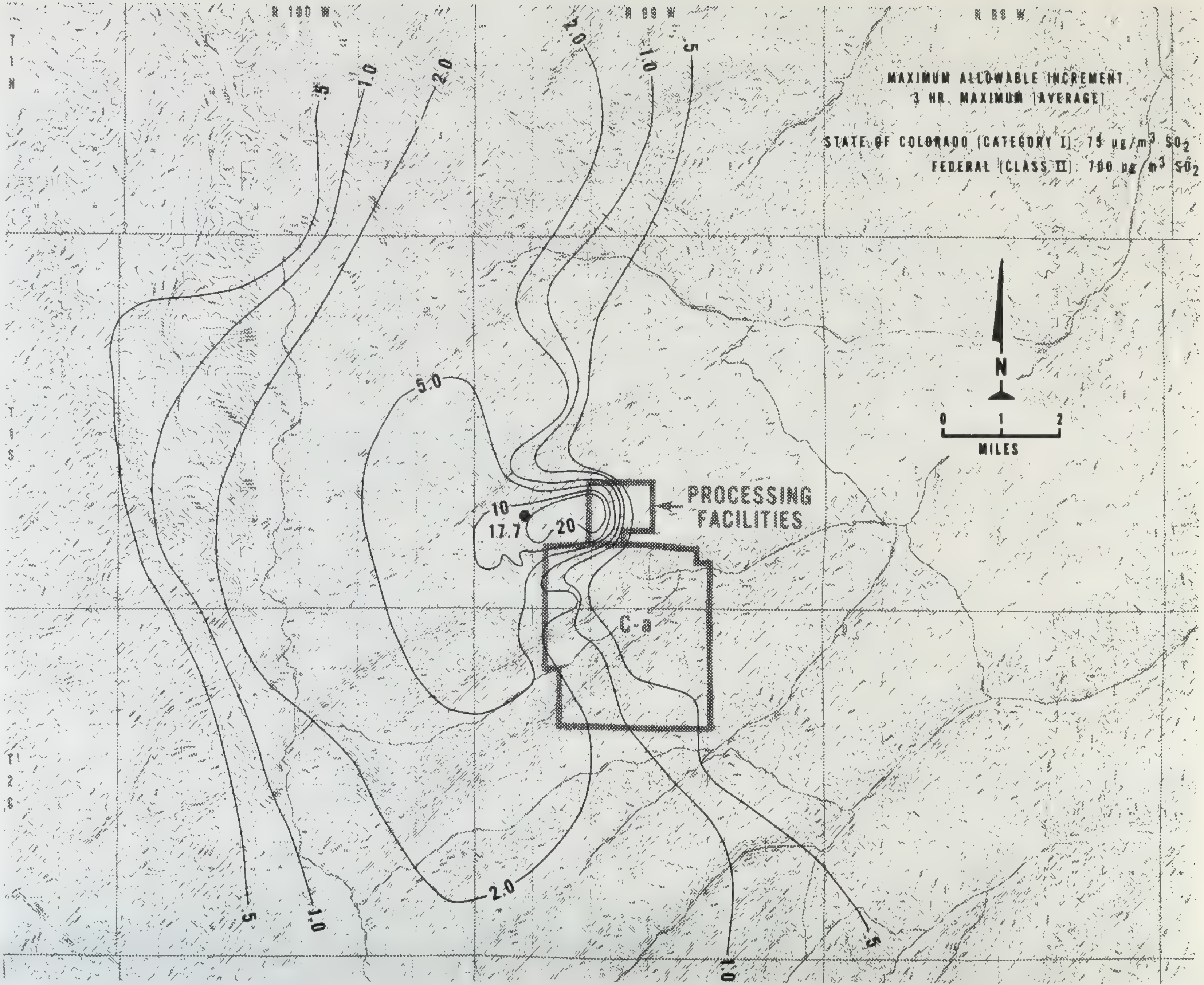


Figure 9-5-8 Phase I, 3 Hr. Maximum Average SO_2 Concentration Isopleths μg/m^3, Range 0-14 Km.

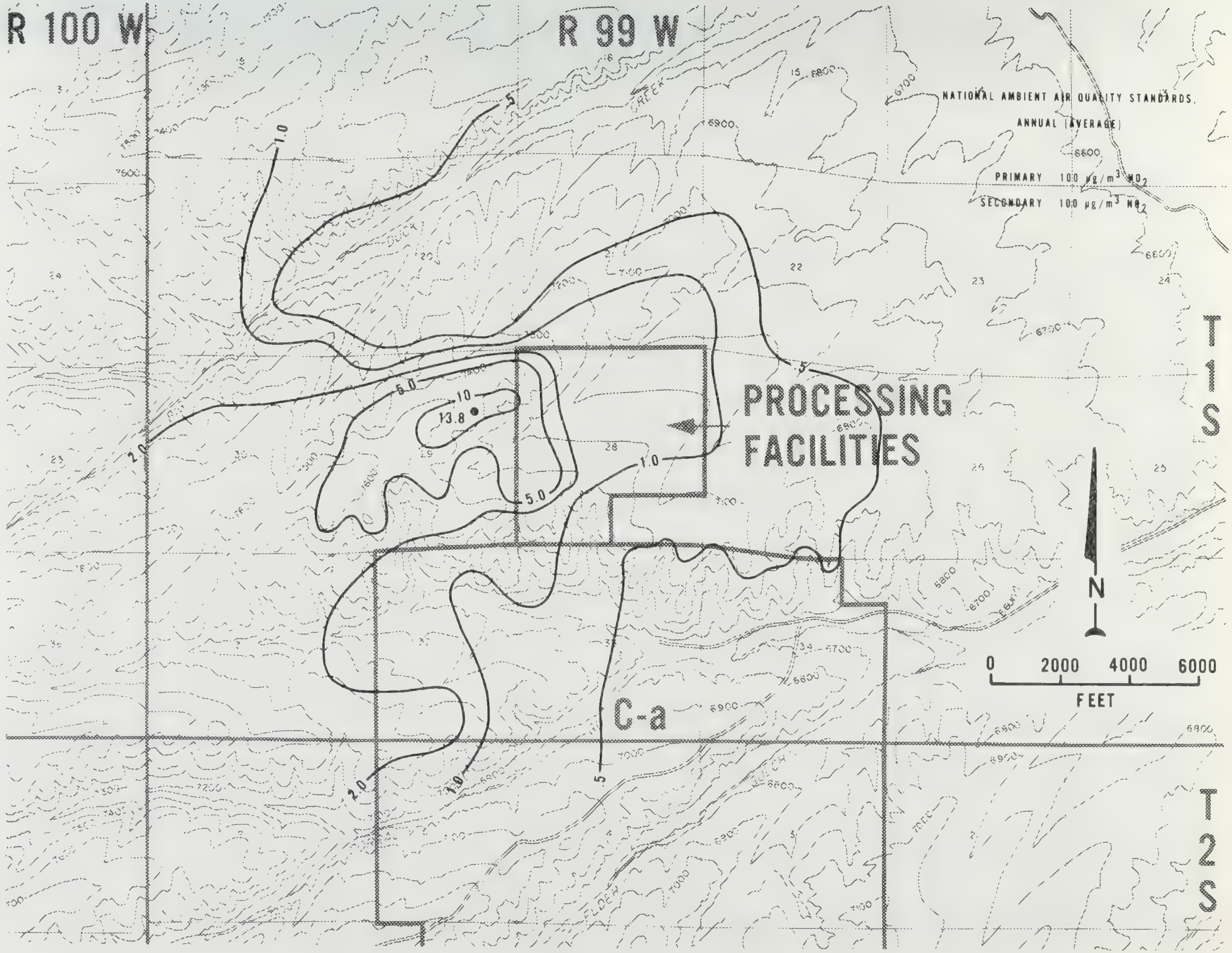


Figure 9-5-9 Phase I, Annual Average NO_2 Concentration Isopleths, $\mu g/m^3$, Range 0-3.5 Km.

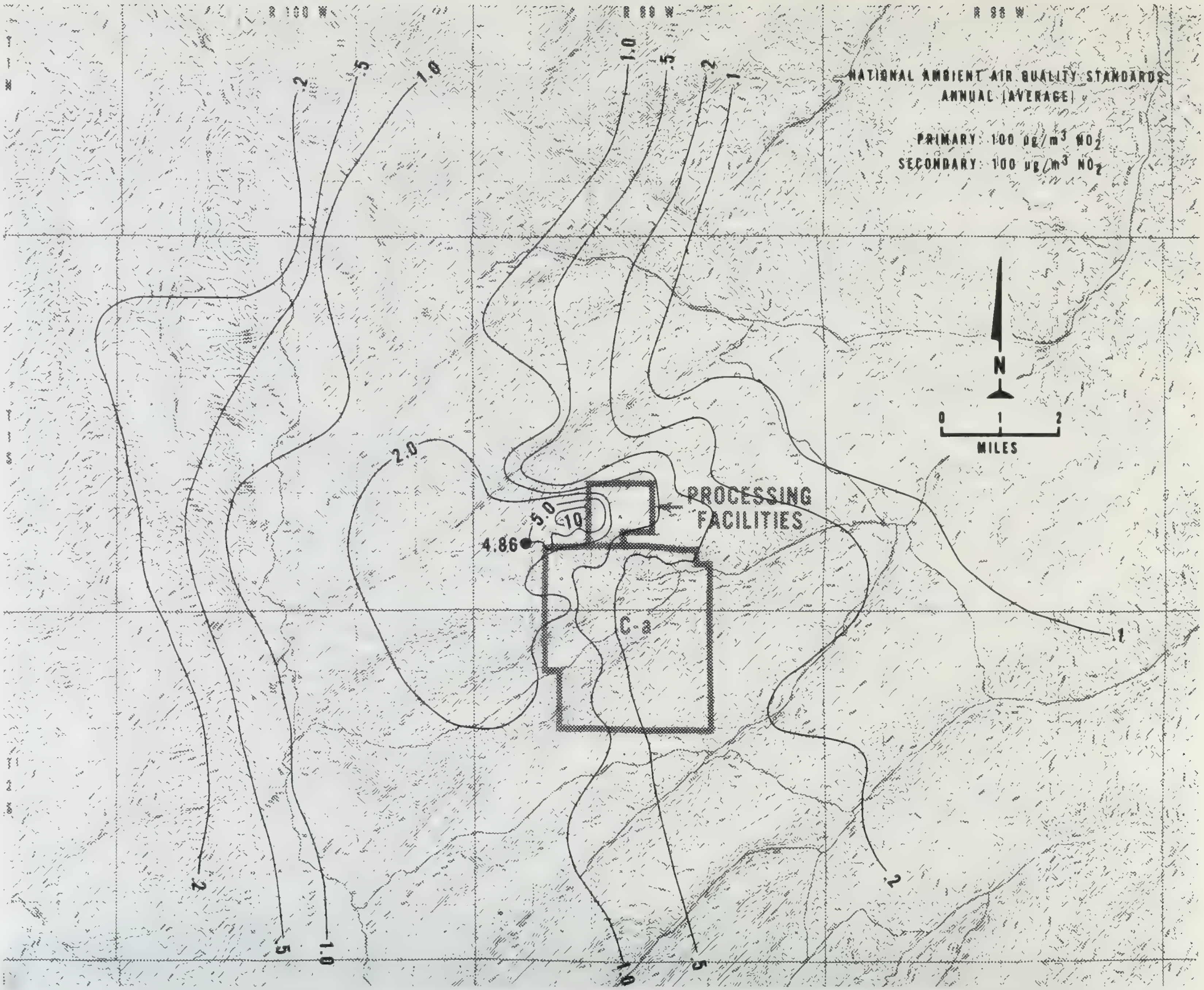


Figure 9-5-10 Phase I, Annual Average NO_2 Concentration Isopleths, μg/m , Range 0-14 Km.

3) Particulates - Figures 9-5-11 and 9-5-12 show the expected ground level concentration increments of particulates during Phase I - Stage 2 operations. The particulate concentration patterns are more complex than the SO_2 and NO_2 patterns due to the greater number of sources. The maximum off site concentration is only 3.5 μ g/m^3 compared with the Federal incremental standard of 10 μg/m^3 over an annual period (Table 9-5-13). The Federal standard is expressed as a geometric mean, while the predicted increments shown on the plots are arithmetic means. A geometric mean, however, is always less than an arithmetic mean. Therefore, it is apparent that the particulate increments will be within presently applicable standards.

The expected 24-hr maximum increment in ground level particulate concentration from Phase I operations is presented in Figures 9-5-13 and 9-5-14. As with the worst case increments to the short-term maximums for SO_2 and non-methane hydrocarbons, the 24-hr maximum increments for particulates were calculated under light winds and stable conditions. The maximum increments of particulates off site are about 22 μg/m^3 compared to the Federal Class II non-deterioration regulation of 30 μg/m^3 for a 24-hr maximum (Table 9-5-13). The averaging interval normalization technique described in the modeling methodology section was applied to the evaluation of the 24-hr particulate concentration average.

4) Non-Methane Hydrocarbons - Figures 9-5-15 and 9-5-16 show the calculated additional levels of non-methane hydrocarbon ground level 3-hr maximum concentrations resulting from Phase I operations. The highest predicted off site increment is 156 μg/m^3. This will result in non-methane hydrocarbon concentrations in excess of the NAAQS regulation of 160 μg/m^3 (Table 9-5-12) when the natural background is accounted for. During Phase I operations, tank farm emissions will contribute the largest part of the calculated non-methane hydrocarbon levels. Methods of estimating tank vapor losses are imprecise. They are probably conservative when applied to the 6-9 am time interval specified in the standards since during this time period the tanks will be relatively cool. Nonetheless, Phase I - Stage 1 operations will

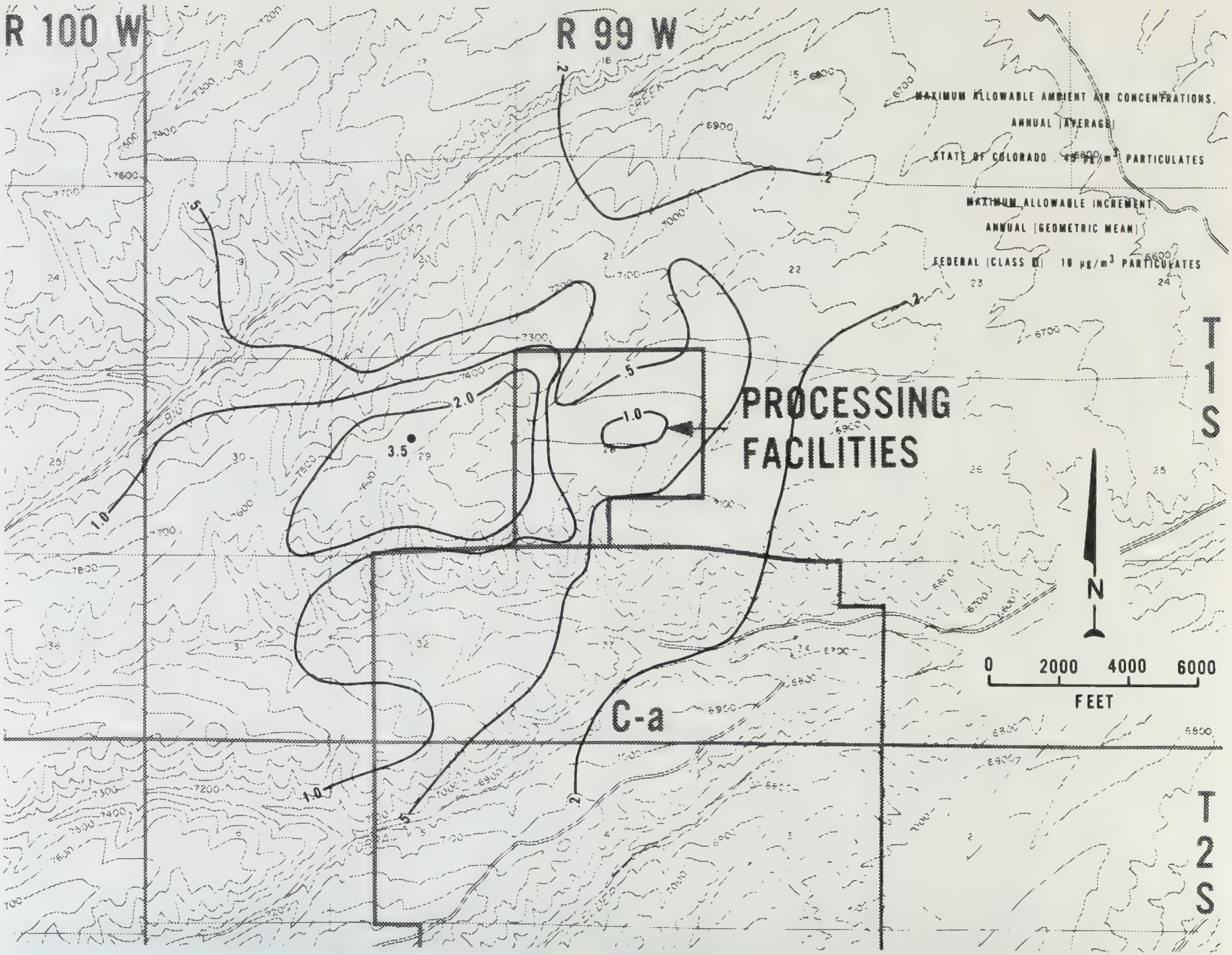
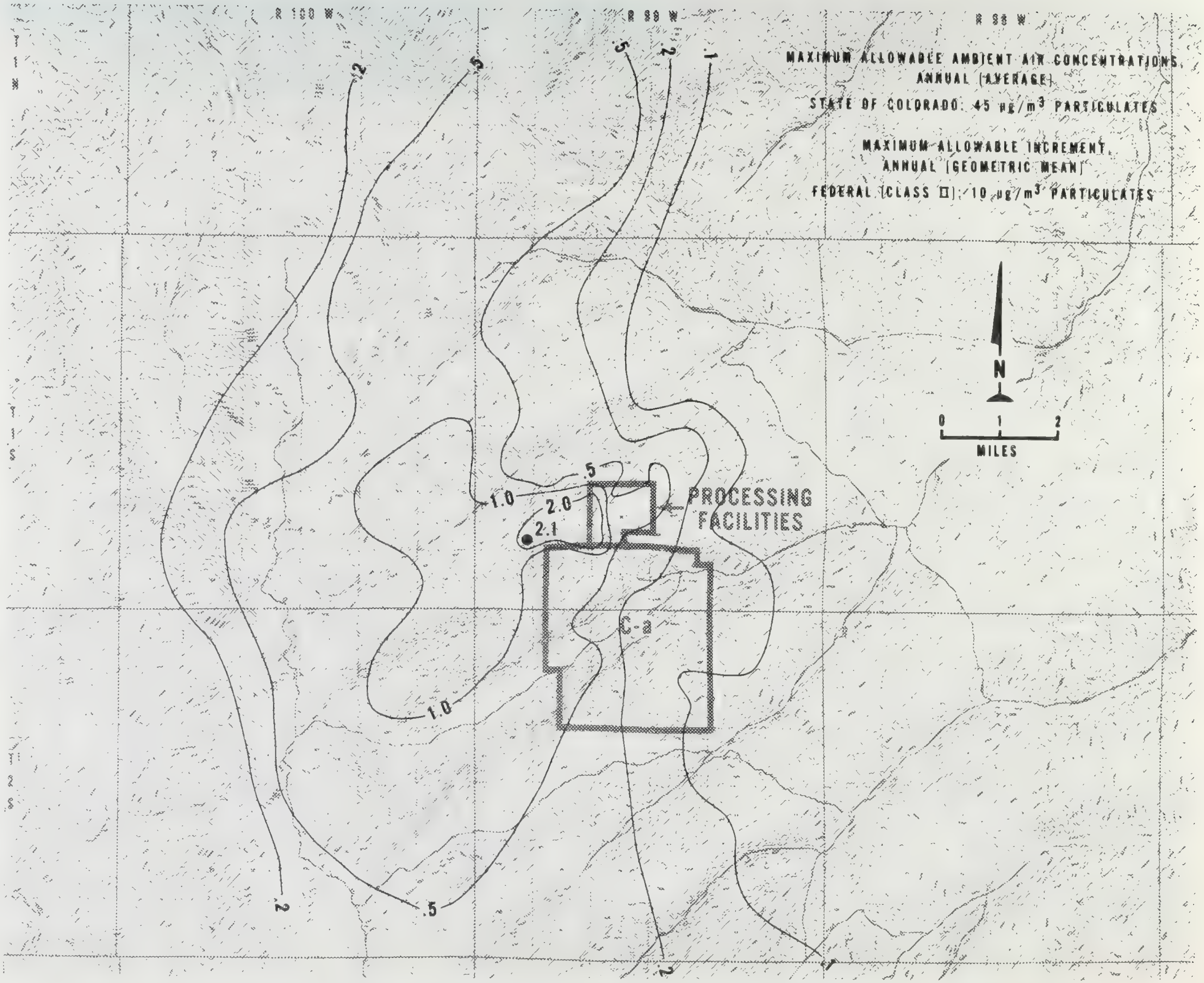

R 100 W
R 99 W
T 1 S
T 2 S
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS,
ANNUAL (AVERAGE)
STATE OF COLORADO . 45 μg/m^3 PARTICULATES
MAXIMUM ALLOWABLE INCREMENT,
ANNUAL (GEOMETRIC MEAN)
FEDERAL (CLASS II) 19 μg/m^3 PARTICULATES
PROCESSING FACILITIES
C-a
3.5
2.0
1.0
.5
.2
N
0
2000
4000
6000
FEET

Figure 9-5-11 Phase I, Annual Particulate Concentration Isopleths, μg/m^3, Range 0-3.5 Km..



R 100 W
R 99 W
R 98 W
T 1 N
T 1 S
T 2 S
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS,
ANNUAL (AVERAGE)
STATE OF COLORADO: 45 μg/m3 PARTICULATES
MAXIMUM ALLOWABLE INCREMENT,
ANNUAL (GEOMETRIC MEAN)
FEDERAL (CLASS II): 10 μg/m3 PARTICULATES
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
.1
.2
.5
1.0
2.0
2.1

Figure 9-5-12 Phase I Annual Particulate Concentration Isopleths, $\mu g/m^3$, Range 0-14 Km.

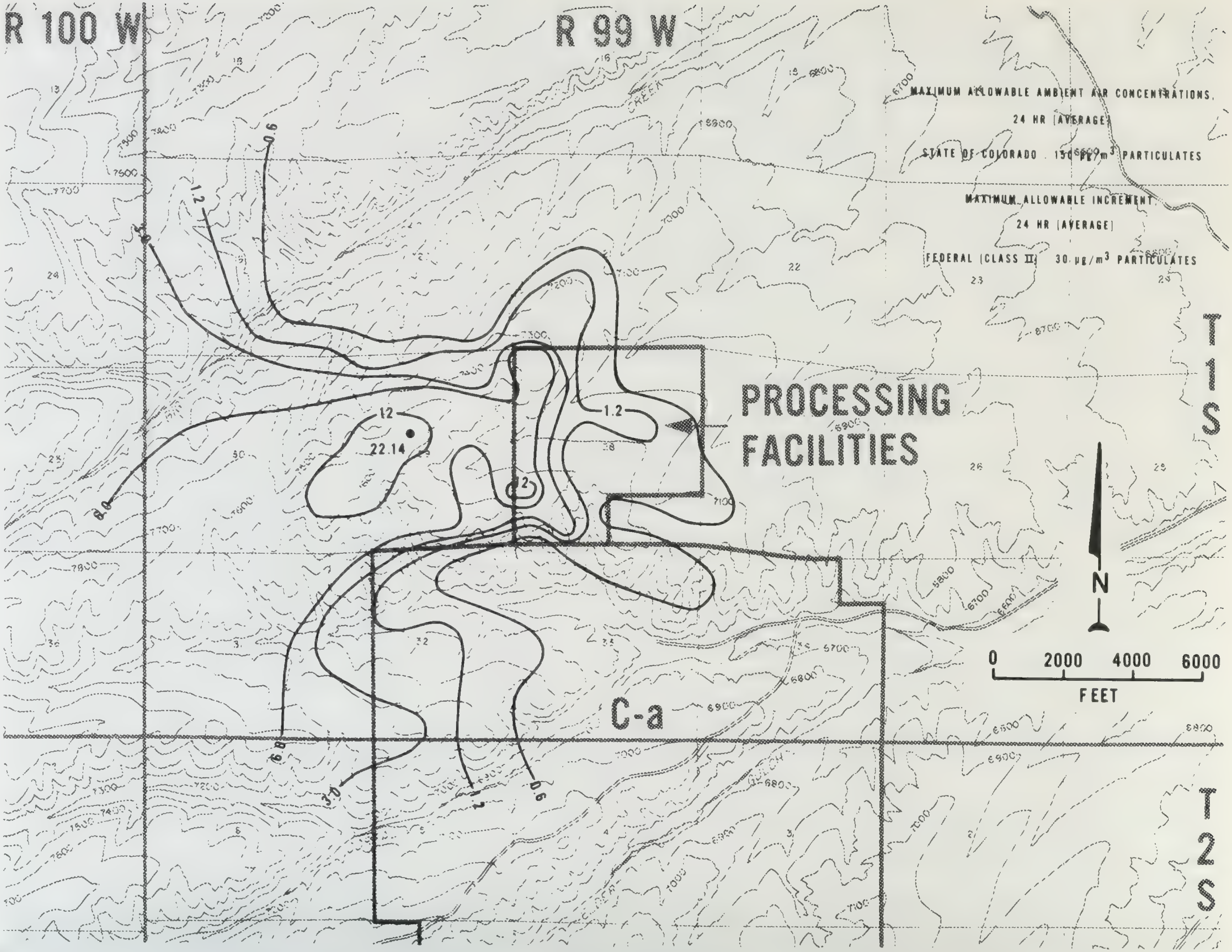
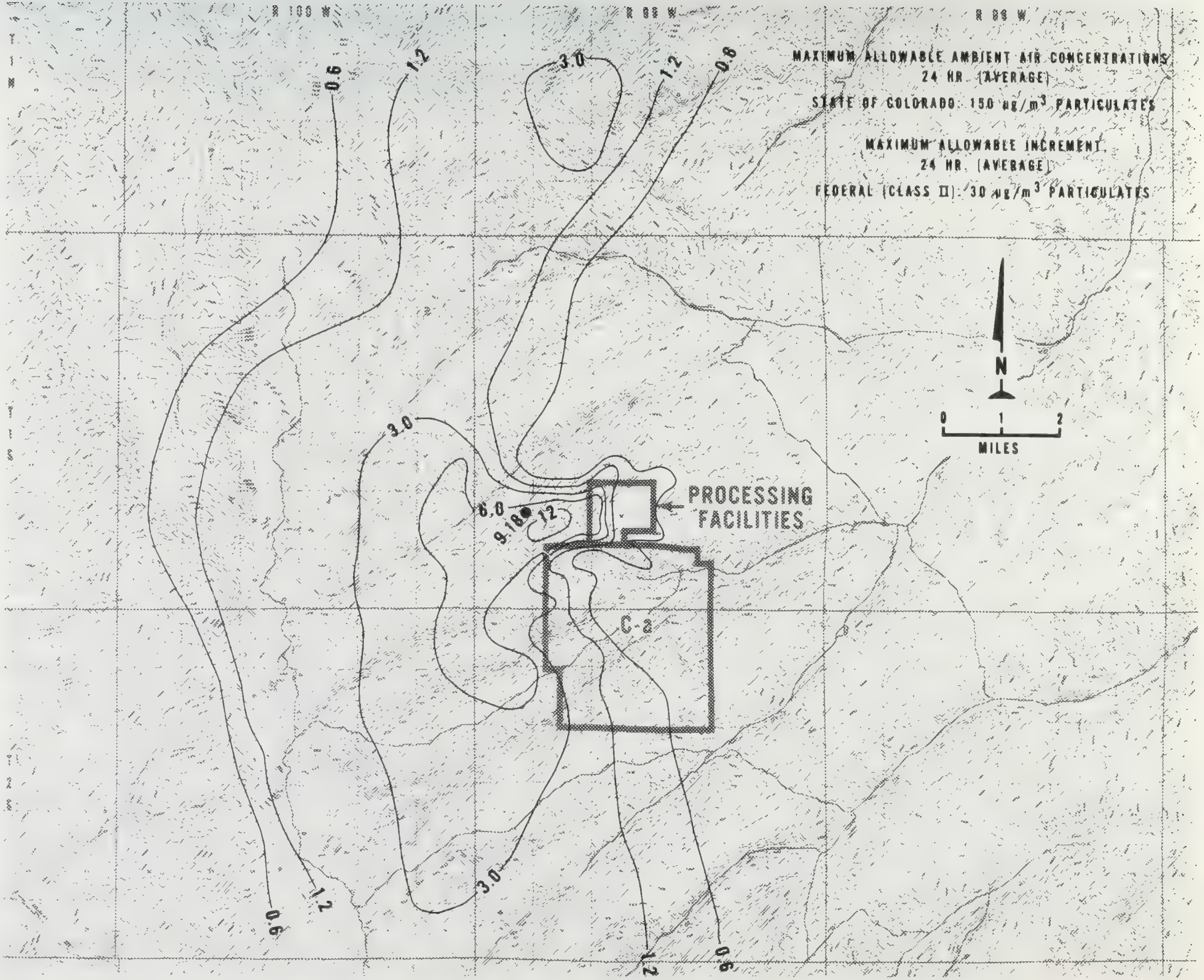

R 100 W
R 99 W
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS.
24 HR (AVERAGE)
STATE OF COLORADO . 150 μg/m3 PARTICULATES
MAXIMUM ALLOWABLE INCREMENT.
24 HR (AVERAGE)
FEDERAL (CLASS II) 30 μg/m3 PARTICULATES
T 1 S
T 2 S
PROCESSING FACILITIES
C-a
N
0 2000 4000 6000
FEET
22.14
12
1.2
0.6
3.0
6.0

Figure 9-5-13 Phase I, 24 Hr. Maximum Average Particualte Concentration Isopleths, $\mu g/m^3$, Range 0-3.5 Km.



R 100 W
R 99 W
R 98 W
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS
24 HR. (AVERAGE)
STATE OF COLORADO: 150 μg/m³ PARTICULATES
MAXIMUM ALLOWABLE INCREMENT,
24 HR. (AVERAGE)
FEDERAL (CLASS II): 30 μg/m³ PARTICULATES
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
0.6
1.2
3.0
6.0
9.18
12

Figure 9-5-14 Phase I, 24 Hr. Maximum Average Particulate Concentration Isopleths, $\mu g/m^3$, Range 0-14 Km.

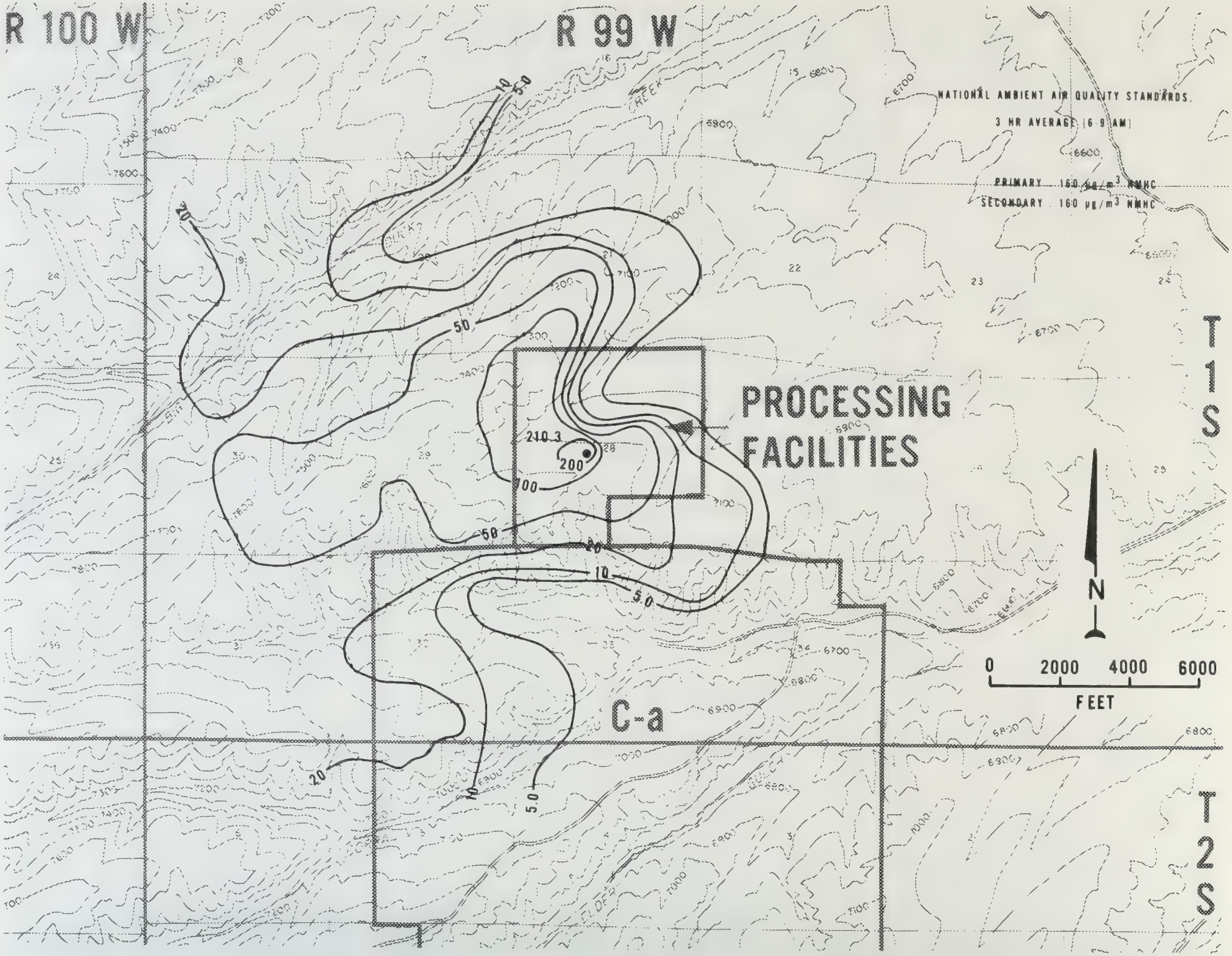


Figure 9-5-15 Phase I, 3 Hr. Maximum Average NMHC Concentration Isopleths, $\mu g/m^3$, Range 0-3.5 Km.

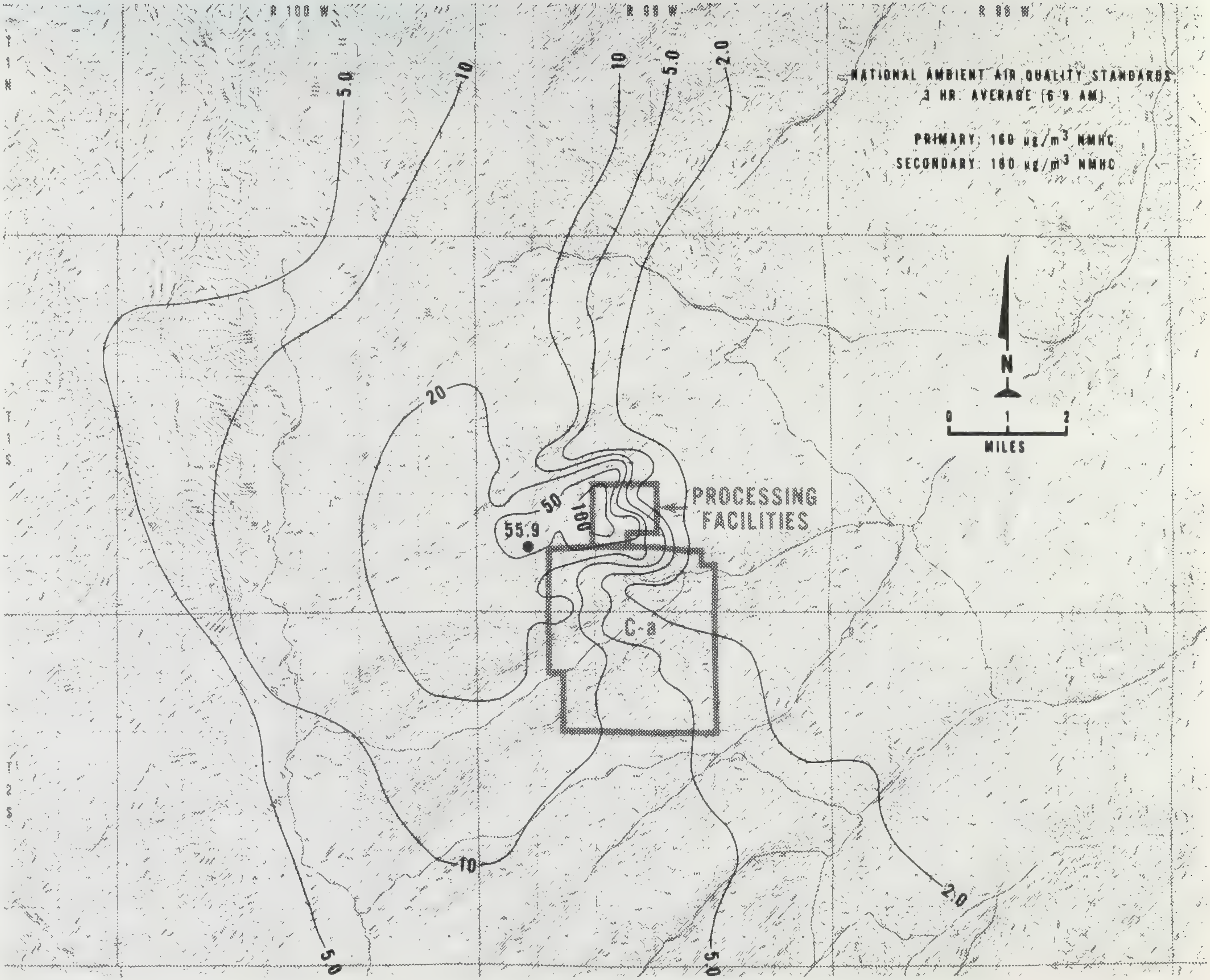


Figure 9-5-16 Phase I, 3 Hr. Maximum Average NMHC Concentration Isopleths, µg/m^3, Range 0-14.

comply with non-methane hydrocarbon standards since emissions for Stage 1 are 50% of those for Stage 2. Phase I - Stage 1 operations and effects will be carefully monitored and, if data indicate it is necessary, an engineering design will be developed for Stage 2 which will comply with the standard.

b. Phase II Operations - A summary comparison of modeling results for Phase II operations with applicable standards is given in Table 9-5-21. A more detailed discussion of the modeling by individual pollutant follows. A large portion of the Phase I results discussion is applicable to Phase II and hence only significantly different aspects are presented here.

1) Sulfur Dioxide - In general, the modeling predicts that Phase II operations will meet all of the present applicable ambient air and significant deterioration standards set by the EPA. In addition, the particulate loading produced by the plant will meet the State of Colorado particulate regulations. Within the present classification of the Piceance Creek basin as Category I, the modeling analysis predicts that the proposed Phase II facility will not meet the current short-term ambient SO_2 standards set by the State of Colorado. The operations, however, will meet all applicable standards should the area be redesignated as Category II by the State of Colorado.

Figures 9-5-17 through 9-5-19 present the annual average contribution from Phase II operations to the SO_2 ground level concentrations. The highest off site predicted values are approximately 2 $\mu g/m^3$ about 5 km southwest of the facility. This point is just west of the present location of the Site 1 monitoring station which is part of the baseline monitoring program for Tract C-a. The operational monitoring Site 6 (Section 11, Chapter 2) was chosen to monitor air quality parameters at this point. Another off site high point is on the ridges (elevation 7,500 ft above MSL) about 2 to 3 km west of the plant site. The applicable State regulations for annual average SO_2 concentration increments is 3 $\mu g/m^3$ under Category I designation (Table 9-5-11).

Table 9-5-21

COMPARISON OF MODELING RESULTS WITH APPLICABLE STANDARDS FOR PHASE II OPERATIONS

Applicable Standard	Emission	Averaging Time	Standard Limit ($\mu g/m^3$)	Maximum Predicted Off-Site Increment Due to Development ($\mu g/m^3$)	Predicted Off-Site Value ($\mu g/m^3$)
State - Category II					
Max. allowable Increment	SO_2	Annual	15	2	NA
		24-hour	100	19	NA
		3-hour	700	94	NA
Federal - Class II					
Max. allowable Increment	SO_2	Annual	15	2	NA
		24-hour	100	19	NA
		3-hour	700	94	NA
	Particulates	Annual*	10	10	NA
		24-hour	30	29	NA
Colorado Ambient Air Quality Standard	Particulates	Annual**	45	10	29
		24-hour	150	29	48
National Ambient Air Quality Standards					
Primary	SO_2	Annual*	80	2	11
		24-hour	365	19	28
Secondary	SO_2	3-hour	1300	94	103
Primary	NO_2	Annual*	100	8	10
Primary	Particulates	Annual*	75	10**	22
		24-hour	260	29	41
Secondary	"	Annual*	60	10**	22
		24-hour	150	29	41
Primary	NMHC	3-hour (6-9 AM)	160	64	129

* Geometric Mean
** Arithmetic Average
NA - Not Applicable

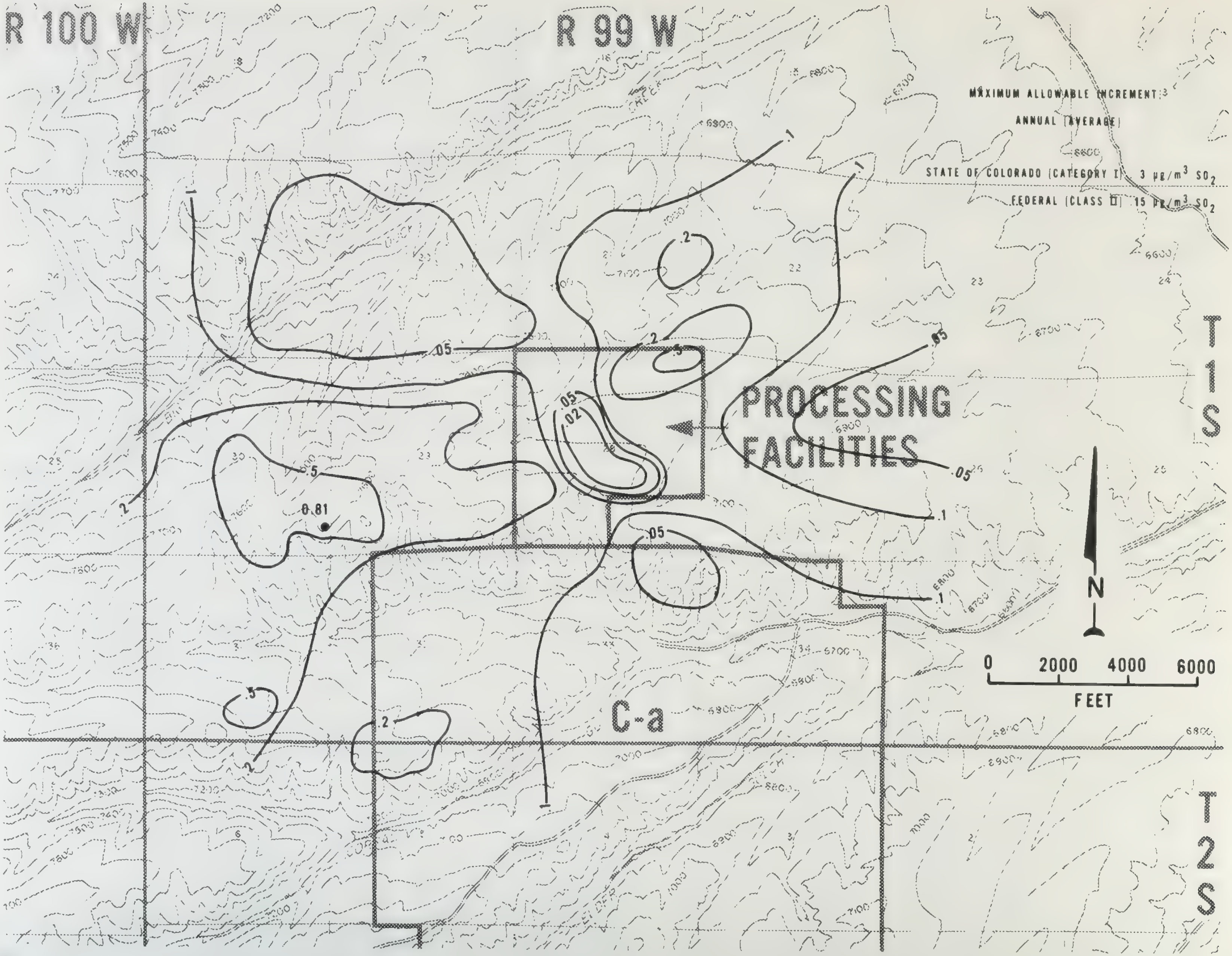

R 100 W
R 99 W
MAXIMUM ALLOWABLE INCREMENT:3
ANNUAL (AVERAGE)
STATE OF COLORADO (CATEGORY I) 3 μg/m3 SO2
FEDERAL (CLASS II) 15 μg/m3 SO2
T 1 S
T 2 S
PROCESSING FACILITIES
C-a
N
0 2000 4000 6000
FEET
.1
.05
.2
.5
.02
0.81

Figure 9-5-17 Phase II, Annual Average SO_2 Concentration Isopleths, $\mu g/m^3$, Range 0-3.5 Km.

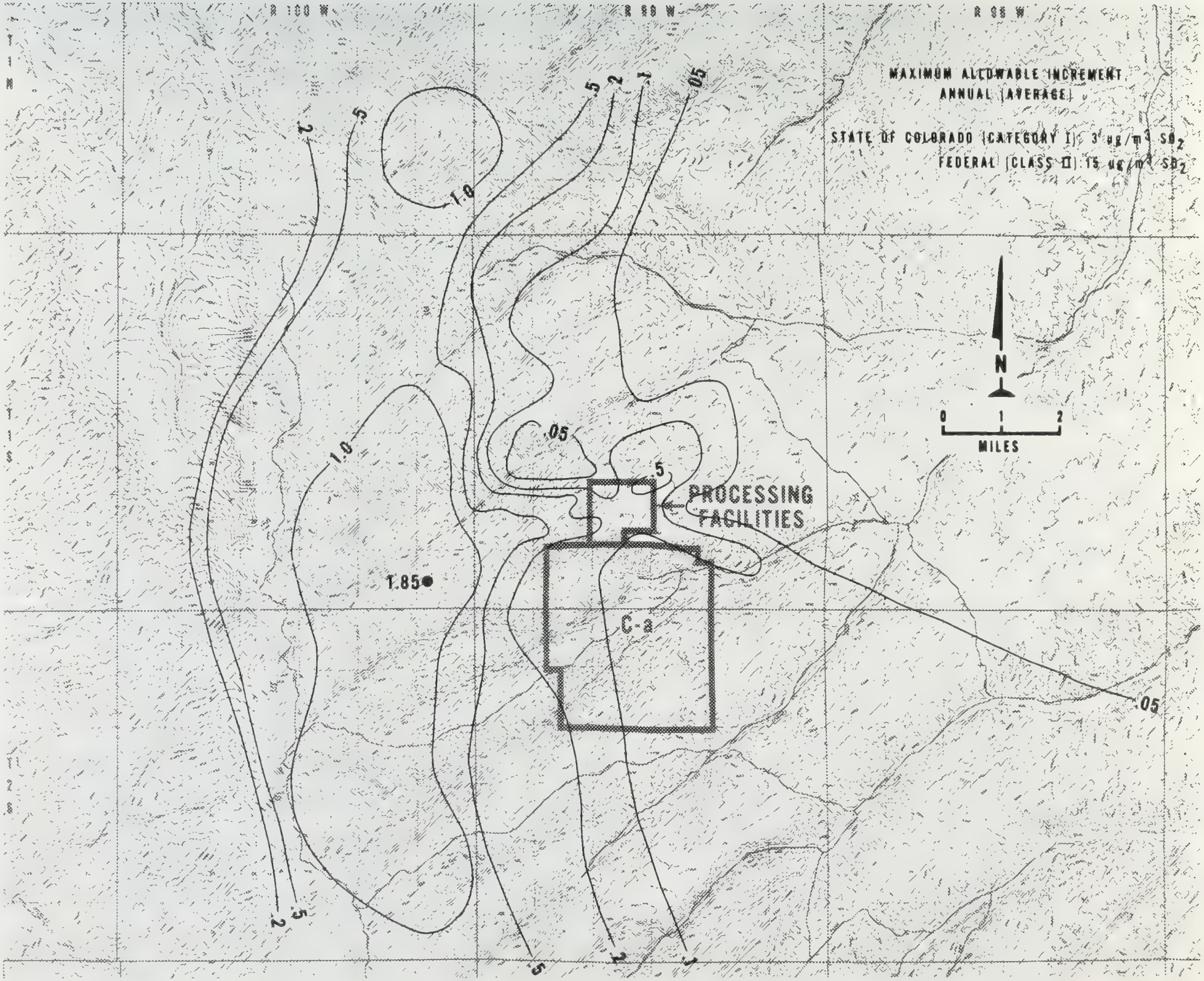


Figure 9-5-18 Phase II, Annual Average SO_2 Concentration Isopleths, $\mu g/m^3$, Range 0-14 Km.

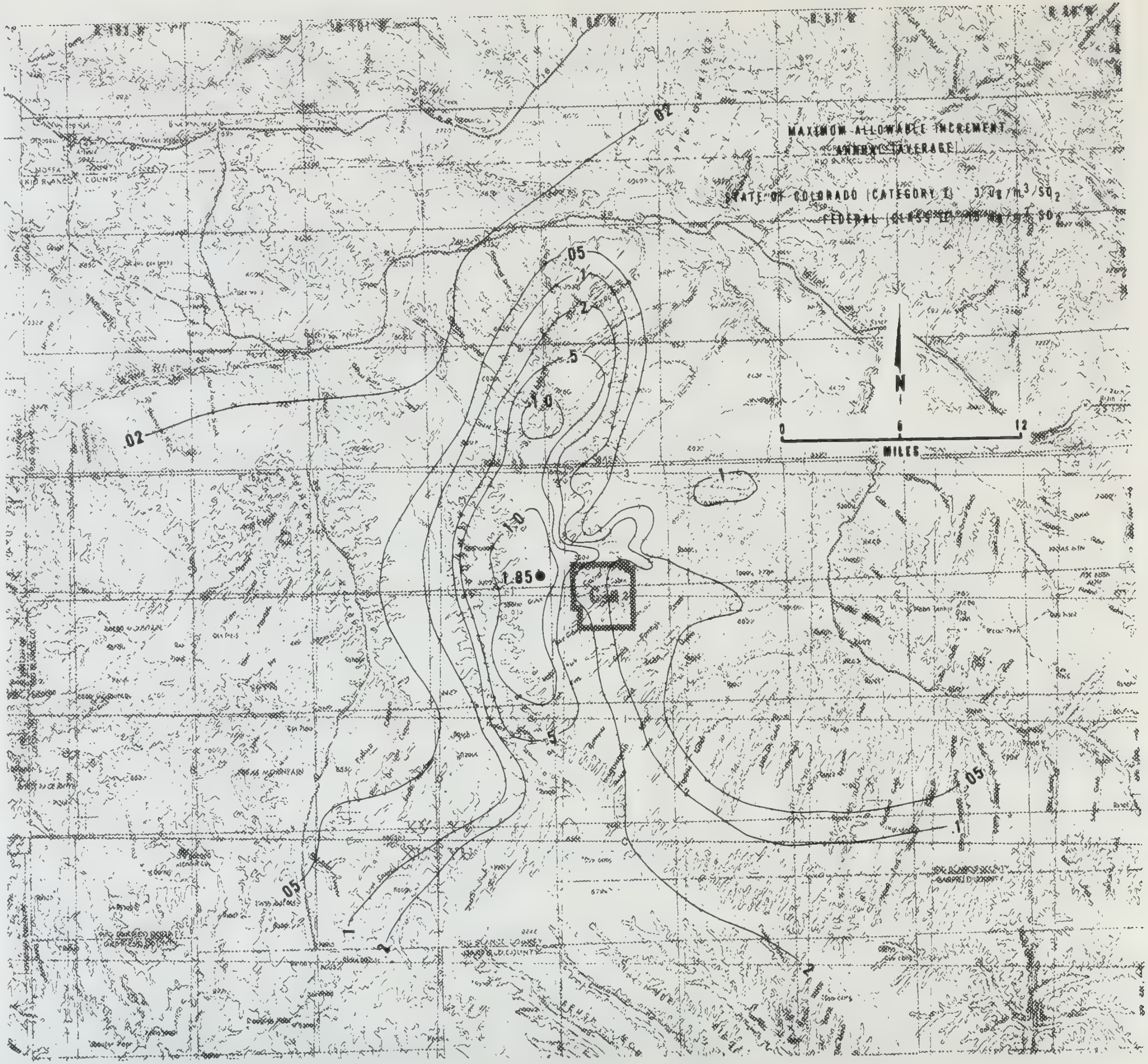

MAXIMUM ALLOWABLE INCREMENT
ANNUAL AVERAGE
STATE OF COLORADO (CATEGORY I) 3 μg/m3/SO2
FEDERAL (CLASS II) 15 μg/m3 SO2
N
0
6
12
MILES
.02
.05
.1
.2
.5
1.0
1.85
.02
.05
.1
.2
.5
.05
.1
.2

Figure 9-5-19 Phase II, Annual Average SO_2 Concentration Isopleths, μg/m^3, Range 0-35 Km.

The 24-hr maximum SO_2 concentrations predicted from Phase II operations are shown in Figures 9-5-20 and 9-5-21. The point of maximum incremental concentration lies in the same area as the annual average point of maximum concentration. The highest predicted value is 19 $\mu g/m^3$. This exceeds the Category I State standards of 15 $\mu g/m^3$. It is, however, well within the Category II designation of 100 $\mu g/m^3$ (Table 9-5-11).

The 3-hr maximum SO_2 concentrations predicted from Phase II operations are shown in Figures 9-5-22 and 9-5-23. The point of maximum incremental concentration lies at approximately the same position as the point of maximum concentration for the 24-hr maximum SO_2 concentration. The value at this point is 94 $\mu g/m^3$ compared to a Category I State standard of 75 $\mu g/m^3$. This value is, however, well within the Category II designation of 700 $\mu g/m^3$ (Table 9-5-11).

2) Nitrogen Dioxide - As with Phase I operation, the annual average concentration of nitrogen dioxide from Phase II operations is within the NAAQS of 100 $\mu g/m^3$ (Table 9-5-12). The expected point of maximum annual average concentration lies due west of the facility about 1 km. The value at this point is 8 $\mu g/m^3$ (Figures 9-5-24 and 9-5-25).

3) Particulates - Phase II operations will contribute a significant amount of dust both from process and mining operations to the ambient natural particulate loading. The predicted annual average particulate concentration increments are shown in Figures 9-5-26 through 9-5-28. The highest (arithmetic average) predicted off site increment is 10 $\mu g/m^3$, which is the Federal Class II significant deterioration standard (Table 9-5-13). As in the Phase I discussion, the Federal standard is for an annual geometric mean, whereas the results of the modeling predictions are expressed as an arithmetic mean. Geometric mean concentrations are always less than the arithmetic mean, typically by a factor of 0.6 to 0.7.

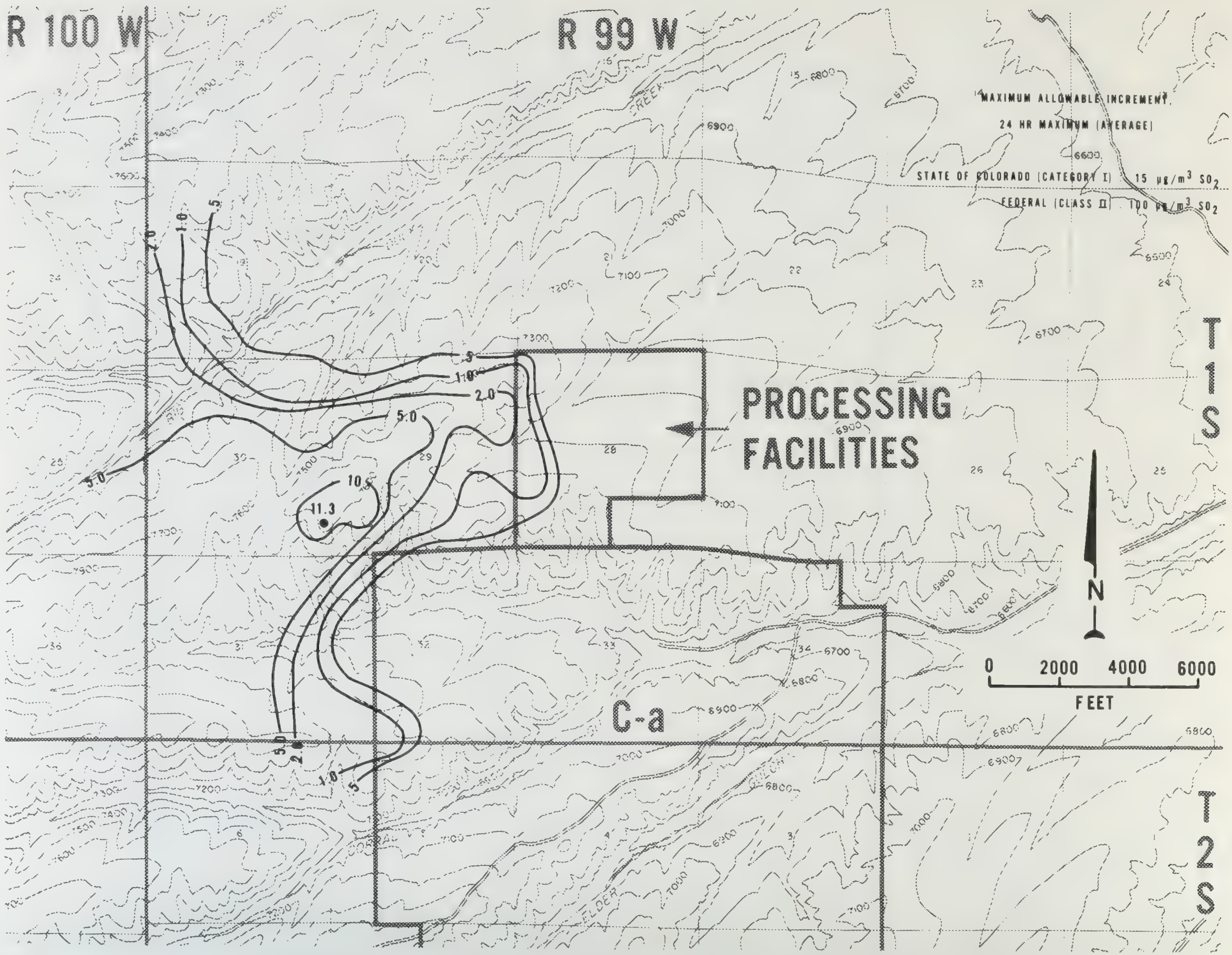
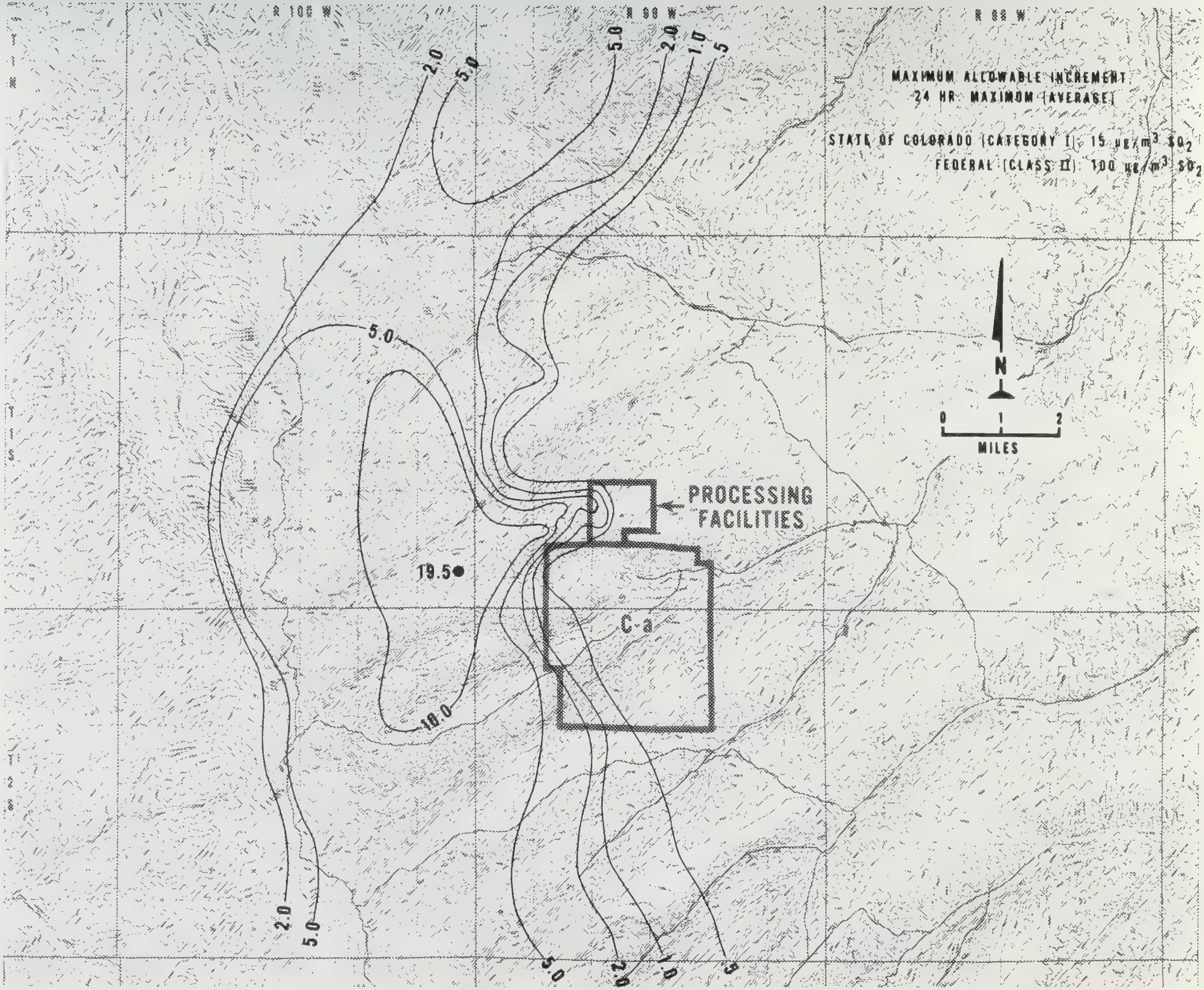


Figure 9-5-20 Phase II, 24 Hr. Maximum Average SO_2 Concentration Isopleths, μg/m^3, Range 0-3.5 Km.



R 100 W
R 99 W
R 98 W
MAXIMUM ALLOWABLE INCREMENT
24 HR. MAXIMUM (AVERAGE)
STATE OF COLORADO (CATEGORY I): 15 μg/m³ SO₂
FEDERAL (CLASS II): 100 μg/m³ SO₂
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
19.5●
10.0
5.0
2.0
1.0
.5

Figure 9-5-21 Phase II, 24 Hr. Maximum Average SO_2 Concentration Isopleths, μg/m³, Range 0-14 Km.

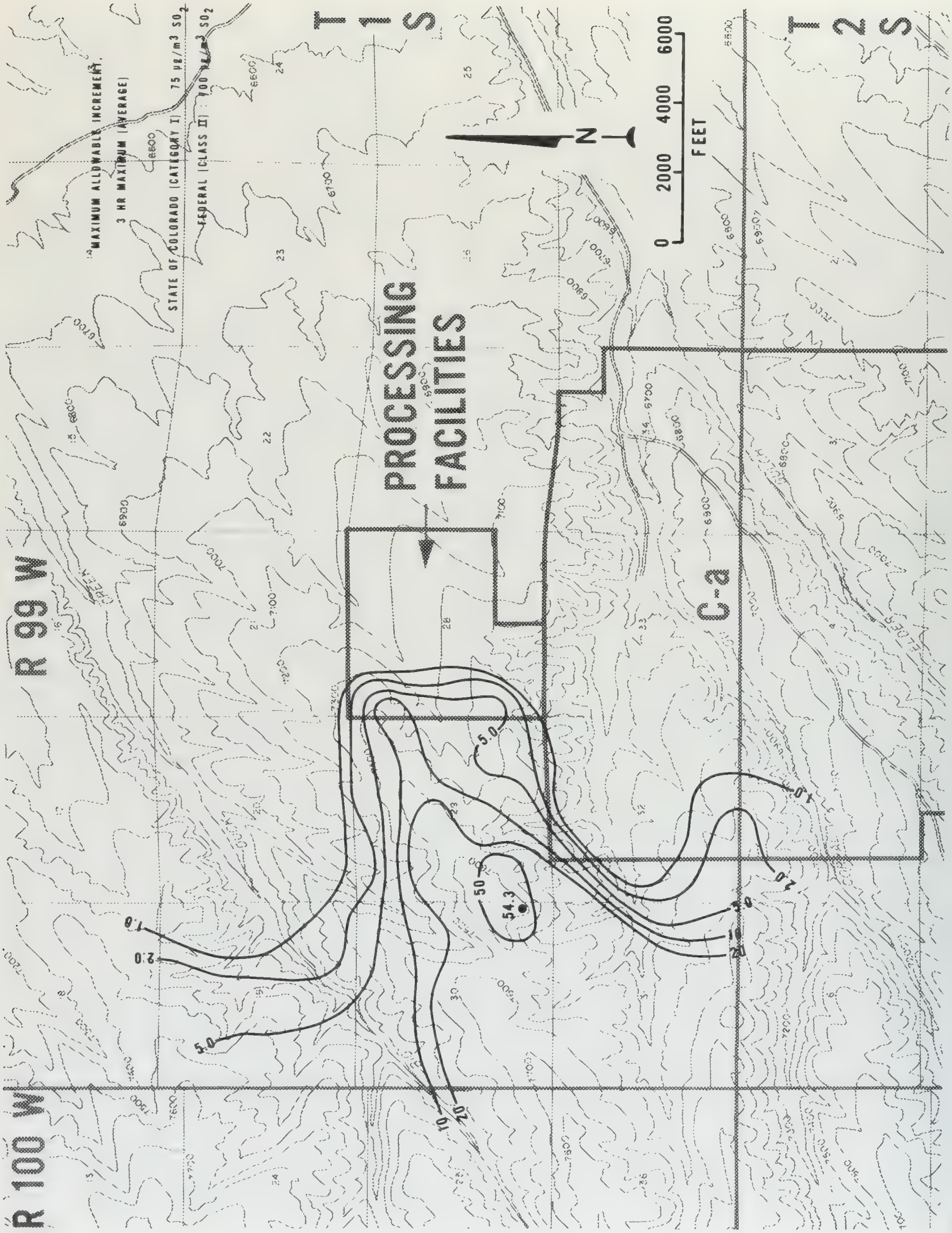


Figure 9-5-22 Phase II, 3 Hr. Maximum Average SO_2 Concentration Isopleths $\mu g/m^3$, Range 0-3.5 Km.

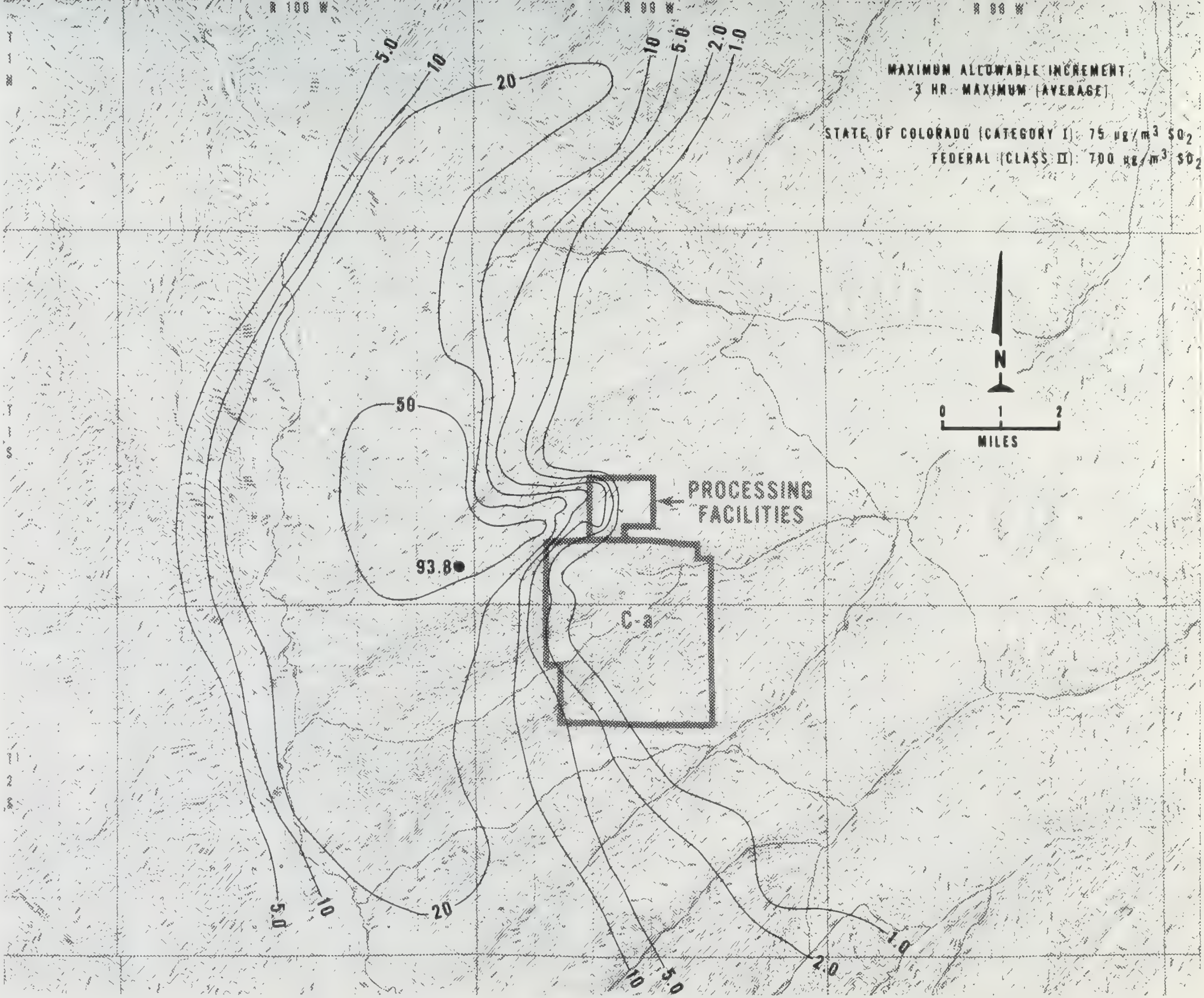

MAXIMUM ALLOWABLE INCREMENT
3 HR. MAXIMUM (AVERAGE)
STATE OF COLORADO (CATEGORY I): 75 μg/m³ SO₂
FEDERAL (CLASS II): 700 μg/m³ SO₂
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
93.8
50
20
10
5.0
2.0
1.0

Figure 9-5-23 Phase II, 3 Hr. Maximum Average SO_2 Concentration Isopleths, μg/m^3, Range 0-14 Km.

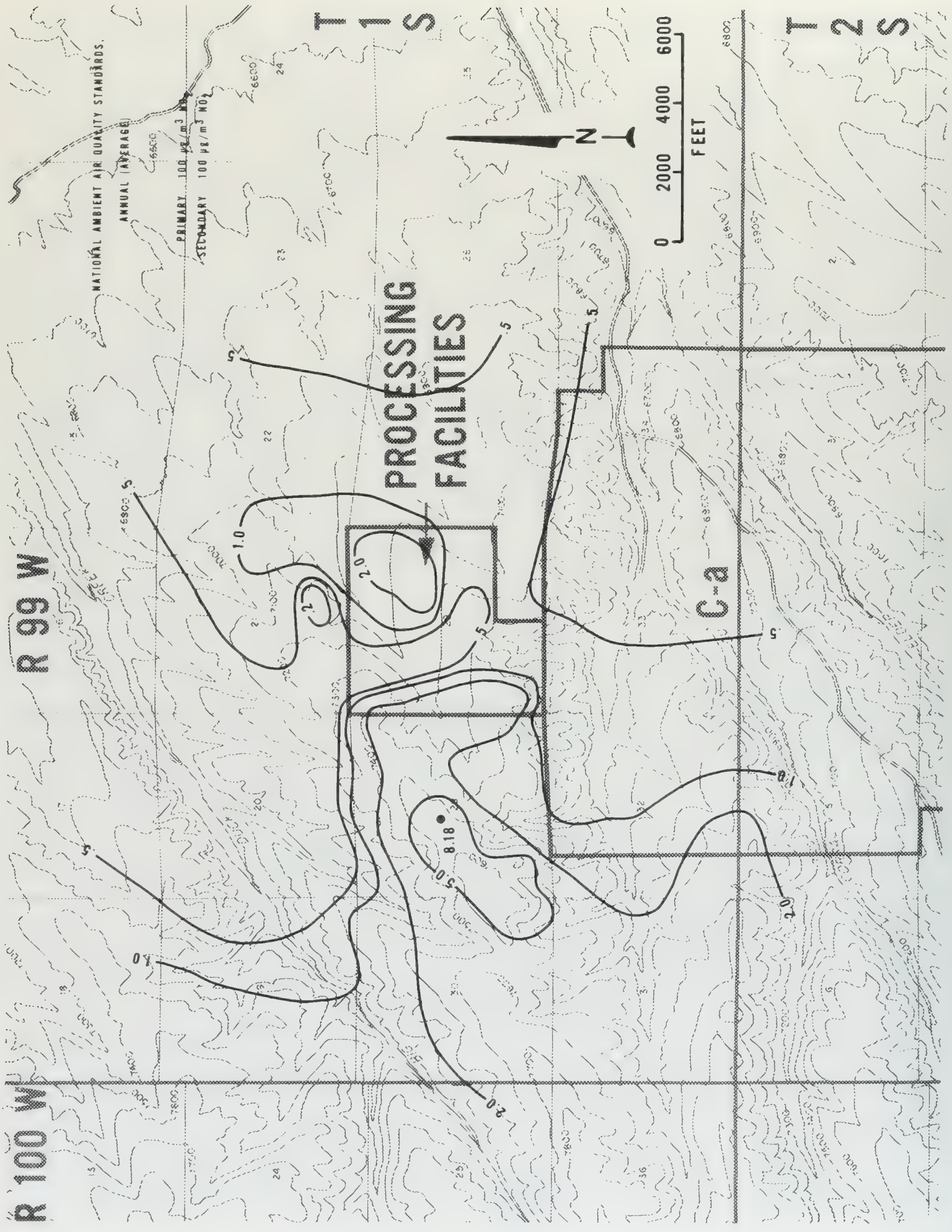


Figure 9-5-24 Phase II, Annual Average NO_2 Concentration Isopleths, $\mu g/m^3$, Range 0-3.5 Km.

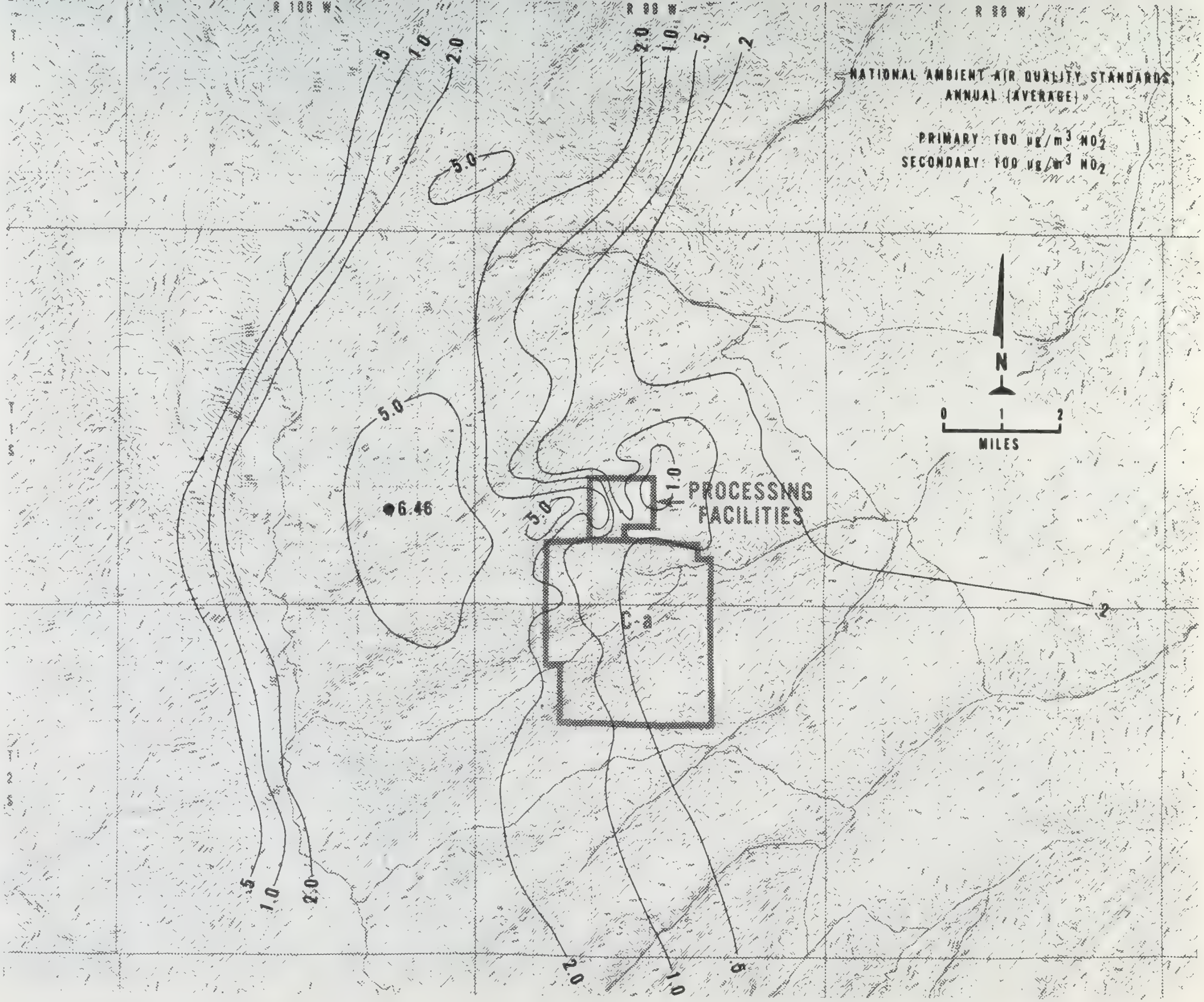


Figure 9-5-25 Phase II, Annual Average NO_2 Concentration Isopleths, $\mu g/m^3$, Range 0-14 Km.

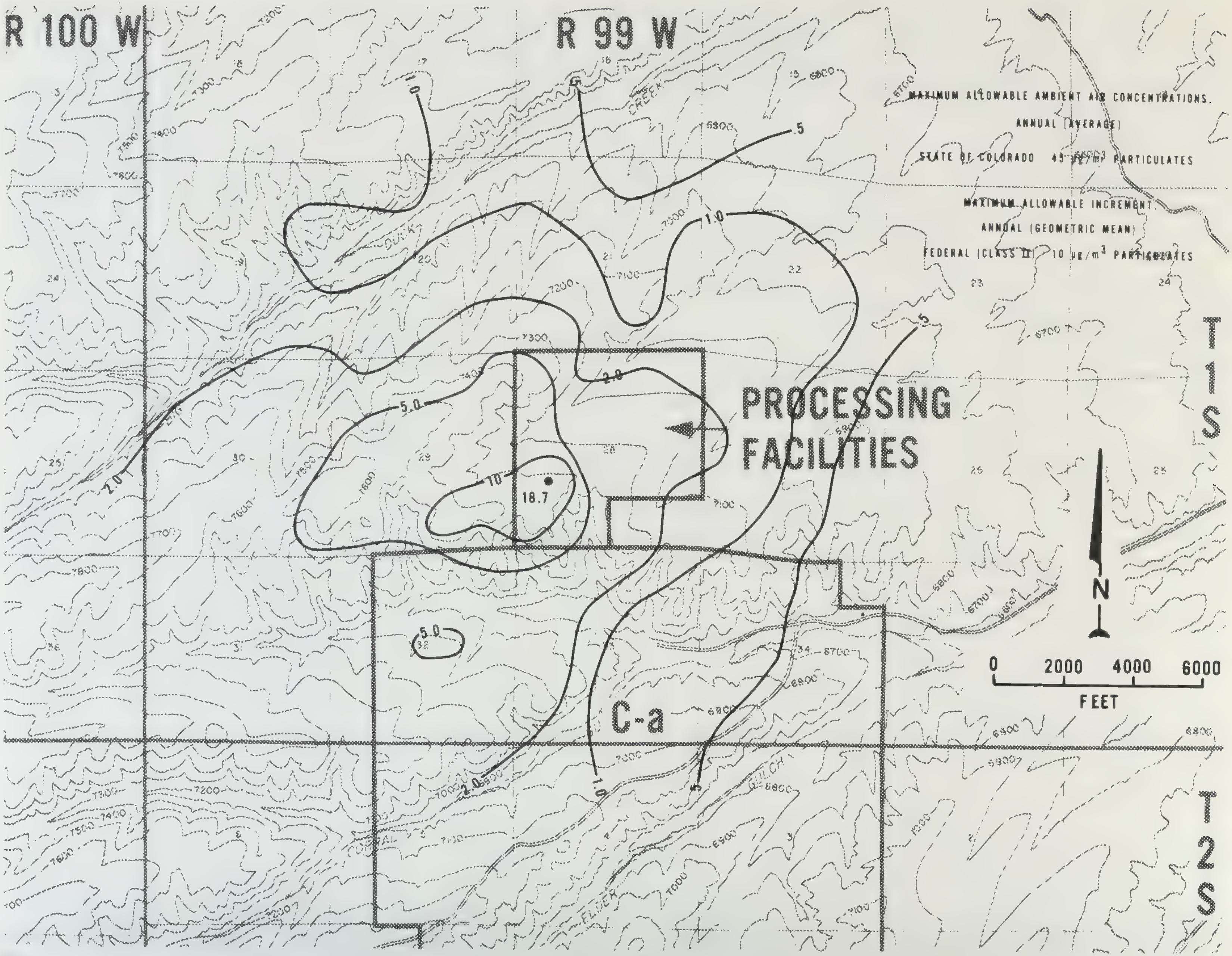

R 100 W
R 99 W
T 1 S
T 2 S
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS.
ANNUAL (AVERAGE)
STATE OF COLORADO 45 μg/m³ PARTICULATES
MAXIMUM ALLOWABLE INCREMENT
ANNUAL (GEOMETRIC MEAN)
FEDERAL (CLASS II) 10 μg/m³ PARTICULATES
PROCESSING FACILITIES
C-a
18.7
10
5.0
2.0
1.0
.5
N
0
2000
4000
6000
FEET
DUCK
CREEK
GULCH
CORRAL
ELDER

Figure 9-5-26 Phase II, Annual Average Particulate Concentration Isopleths, μg/m³, Range 0-3.5 Km.

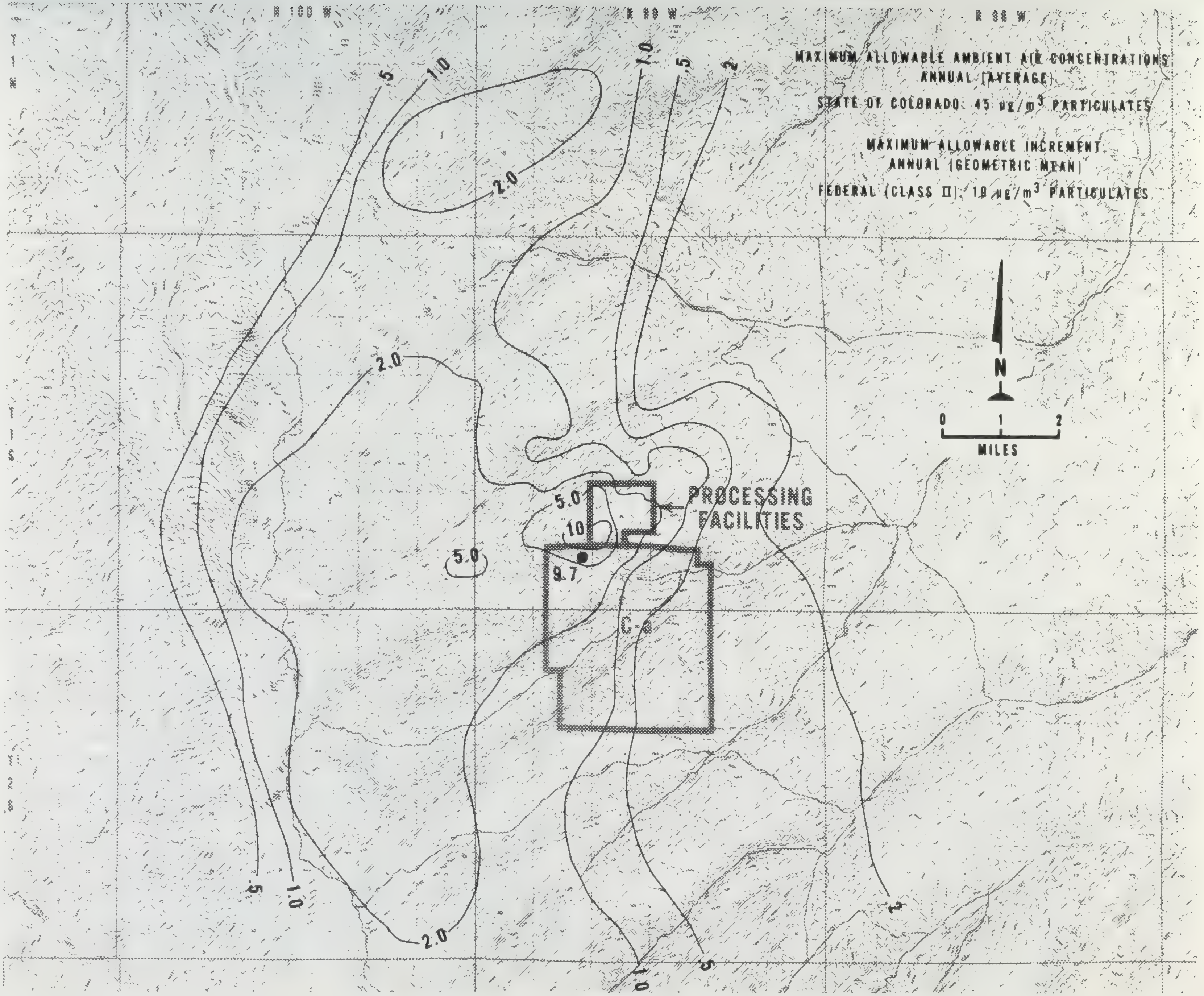

R 100 W
R 99 W
R 98 W
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS
ANNUAL (AVERAGE)
STATE OF COLORADO: 45 μg/m3 PARTICULATES
MAXIMUM ALLOWABLE INCREMENT
ANNUAL (GEOMETRIC MEAN)
FEDERAL (CLASS II): 10 μg/m3 PARTICULATES
N
0
1
2
MILES
PROCESSING FACILITIES
C-a
5.0
10
9.7
5.0
2.0
2.0
2.0
1.0
.5
1.0
.5
.2
.5
1.0
.5
1.0
.2

Figure 9-5-27 Phase II, Annual Average Particulate Concentration Iospleths, μg/m^3, Range 0-14 Km.

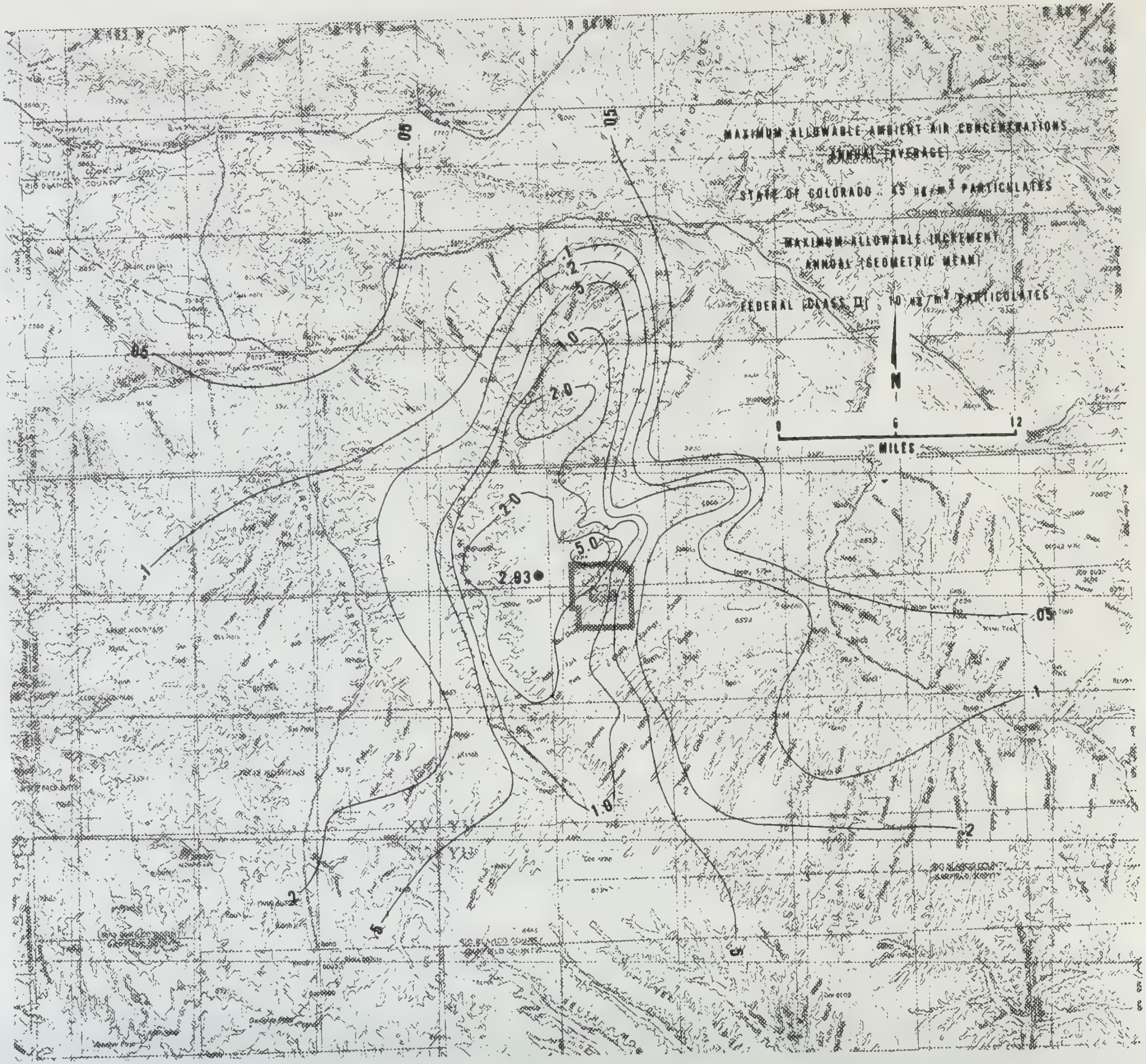

MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS
ANNUAL (AVERAGE)
STATE OF COLORADO . 45 μg/m³ PARTICULATES
MAXIMUM ALLOWABLE INCREMENT
ANNUAL (GEOMETRIC MEAN)
FEDERAL (CLASS II) . 10 μg/m³ PARTICULATES
N
0
6
12
MILES
.05
.05
.05
.05
.1
.2
.5
1.0
2.0
2.0
5.0
2.93●
1.0
.1
.2
.2
.5
.5
.1

Figure 9-5-28 Phase II, Annual Average Particulate Concentration Isopleths, μg/m^3, Range 0-35 Km.

The 24-hr maximum particulate concentration increments from Phase II operations are presented in Figures 9-5-29 and 9-5-30. The highest off site value occurs 1.5 km west-southwest of the facility with a value of 29 $\mu g/m^3$ compared with the Federal significant deterioration standard of 30 $\mu g/m^3$ for the 24-hr maximum (Table 9-5-13). The averaging interval normalization technique described in the modeling methodology section was applied for evaluation of the 24-hr particulate concentration average.

4) Non-Methane Hydrocarbons - Figures 9-5-31 and 9-5-32 illustrate predicted non-methane hydrocarbons ground level 3-hr maximum concentrations resulting from Phase II operations. The point of maximum concentration occurs at approximately the same location as the point of maximum concentration of 3-hr SO_2 averages. The major sources of this pollutant are the same stacks as those for SO_2. The maximum 3-hr concentration of non-methane hydrocarbons is 64 $\mu g/m^3$ compared with the NAAQS regulations of 160 $\mu g/m^3$ (Table 9-5-12).

B. Fumigation Modeling - Fumigation conditions were modeled in order to ensure that they do not define worst case short-term conditions. Fumigation occurs when a plume is released into a thermally stable atmosphere where it is transported downwind as a narrow flat ribbon. Its horizontal rate of spread is only slightly reduced from a more unstable case; however, the vertical dispersion is at a minimum. As the stable layer "burns off," thermally induced vertical mixing develops upward from the ground. When the elevated inversion reaches the level of the plume, high concentrations of pollutants are brought to ground level being mixed within the entire height interval from the elevation of the mixing layer to the surface.

Because the emission sources will be at different absolute elevations, and because the plumes from each of these sources will reach different heights above the surface during a fumigation episode, prediction of these episodes is difficult. This phenomena is a transitory one, not steady-state. The vast majority of days during the baseline monitoring year showed surface

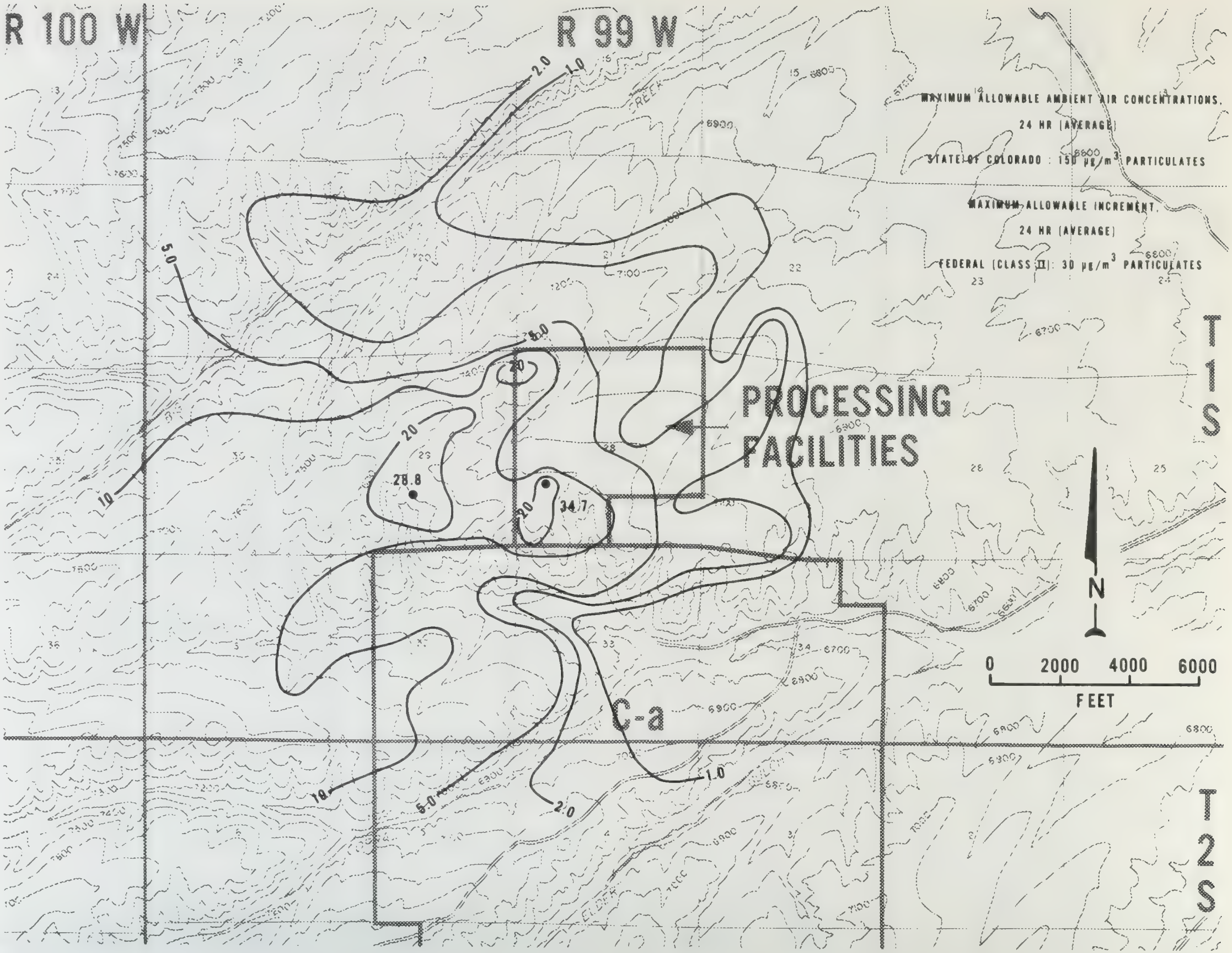

R 100 W
R 99 W
T 1 S
T 2 S
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS.
24 HR (AVERAGE)
STATE OF COLORADO : 150 μg/m³ PARTICULATES
MAXIMUM ALLOWABLE INCREMENT.
24 HR (AVERAGE)
FEDERAL (CLASS II): 30 μg/m³ PARTICULATES
PROCESSING FACILITIES
C-a
N
0
2000
4000
6000
FEET
1.0
2.0
5.0
10
20
28.8
34.7

Figure 9-5-29 Phase II, 24 Hr. Maximum Average Particulate Concentration Isopleths μg/m^3, Range 0-3.5 Km.

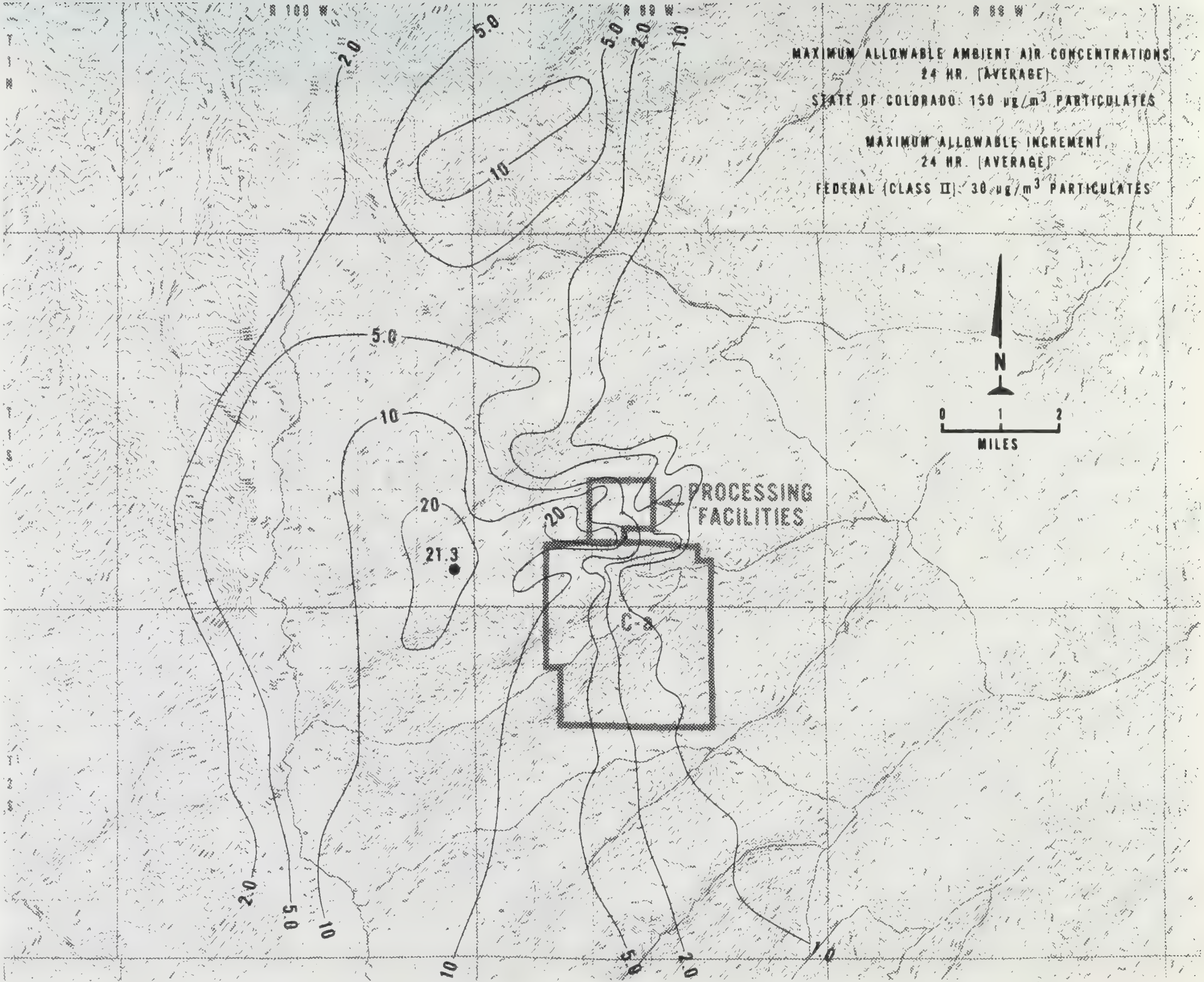

R 100 W
R 99 W
R 98 W
MAXIMUM ALLOWABLE AMBIENT AIR CONCENTRATIONS
24 HR. (AVERAGE)
STATE OF COLORADO: 150 μg/m³ PARTICULATES
MAXIMUM ALLOWABLE INCREMENT
24 HR. (AVERAGE)
FEDERAL (CLASS II): 30 μg/m³ PARTICULATES
N
0 1 2
MILES
PROCESSING FACILITIES
C-a
21.3
20
10
5.0
2.0
1.0

Figure 9-5-30 Phase II, 24 Hr. Maximum Average Particulate Concentration Isopleths, $\mu g/m^3$, Range 0-14 Km.

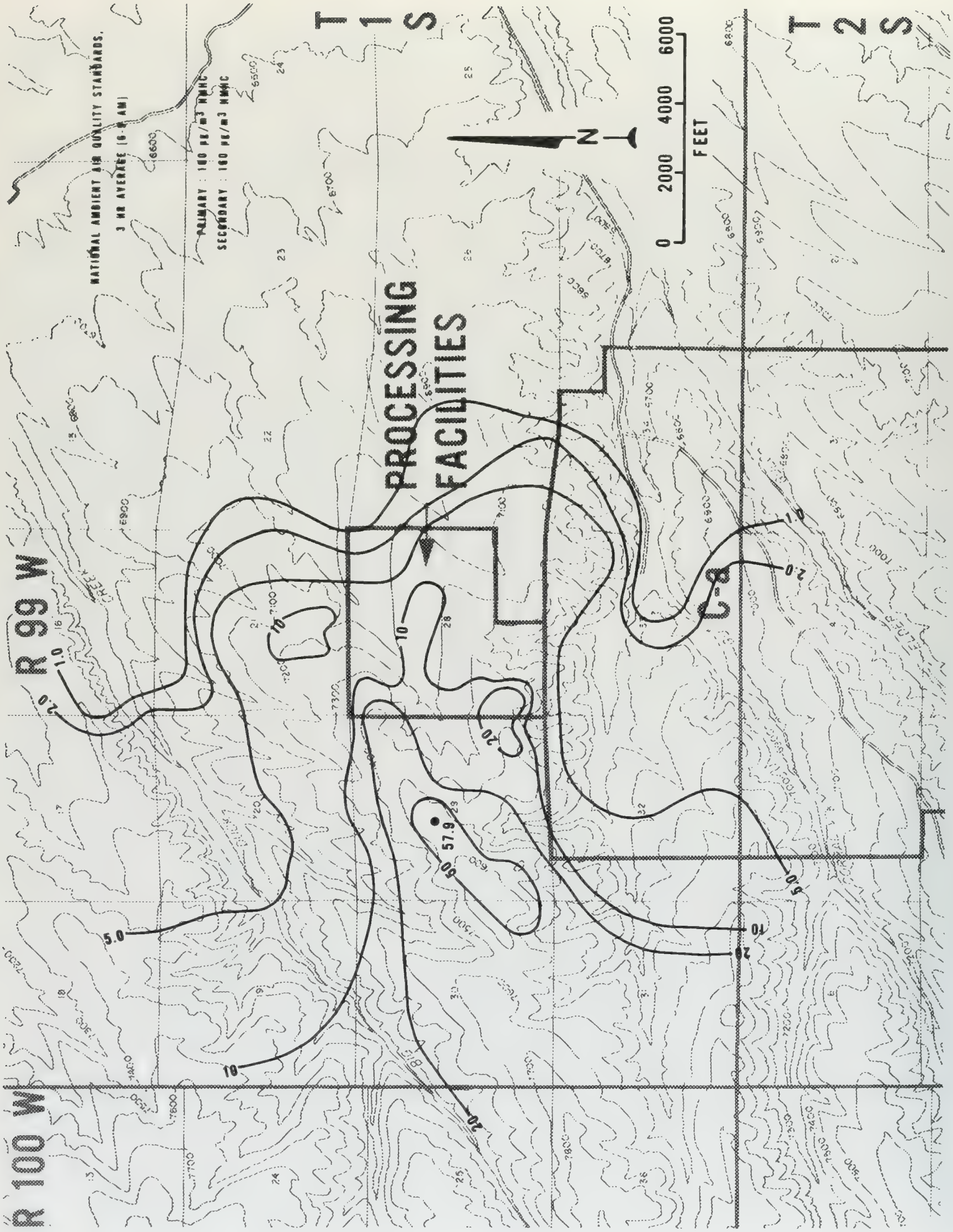


Figure 9-5-31 Phase II, 3 Hr. Maximum Average NMHC Concentration Isopleths, μg/m^3, Range 0-3.5 Km.

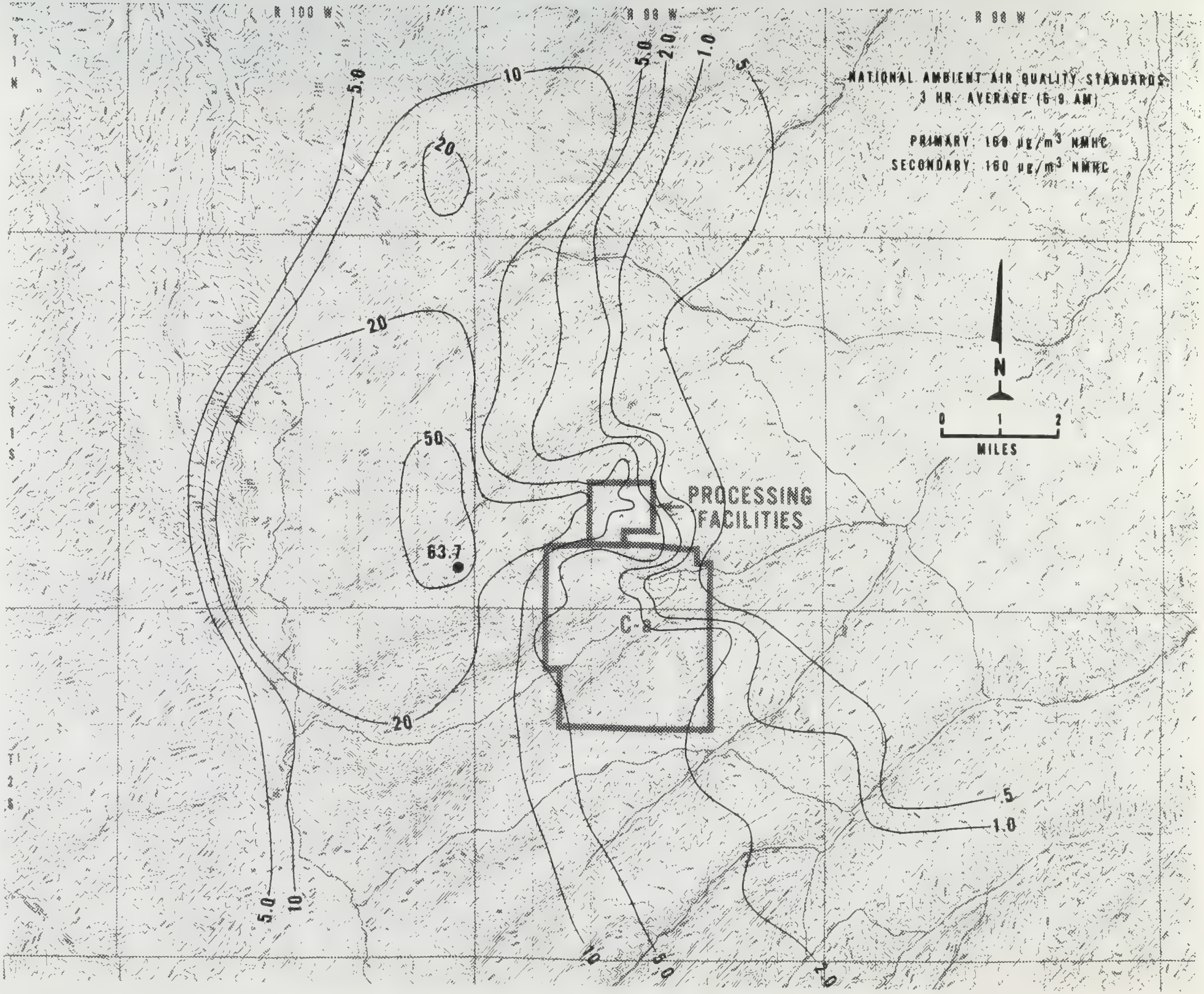


Figure 9-5-32 Phase II, 3 Hr. Maximum Average NMHC Concentration Isopleths, $\mu g/m^3$, Range 0-14 Km.

based inversion breakup within an hour after sunrise. Because of this rapidly changing situation, the predicted concentration from a fumigation episode would not be expected to last more than approximately one hour.

A multiple-source modification of the fumigation model used by the Tennessee Valley Authority (Carpenter, 1971) was used to predict concentrations of SO_2, NMHC, and particulates. The final absolute elevation of each of the plumes was calculated taking into account the source elevation, the stack height, and the plume rise. The final plume rise height was calculated using Brigg's equations (Briggs, 1969). This determined a set of absolute plume center line heights which were ranked from lowest to highest above the surface. These distances of maximum concentration for each time the mixing layer penetrated to the heights of these different plumes was then calculated according to:

$$X_{max} = u\rho C_p H^2/4K$$

where u and H have the same meanings as in the univariate Gaussian equation case and:

K = eddy heat conductivity = $23 \times \exp\left(-96.7 \frac{\Delta\theta}{\Delta z}\right)$

ρ = air density at 7000 ft MSL, $\rho = 0.981$ Kg/m^3

C_p = specific heat of air = 0.24

$\frac{\Delta\theta}{\Delta z}$ = potential temperature gradient = $\frac{\Delta T}{\Delta z} + 0.0098$ (^{o}Celsius/meter)

The time for the mixing layer to reach this altitude, H, is given by:

$$t \text{ (seconds)} = \frac{X_{max}}{u}$$

For multiple sources, the concentration at the point downwind, X_n, at the time the mixing layer height has penetrated to the n^{th} plume, t_n, is given by:

$$\chi_n = \sum_{i=1}^{n} \frac{Q_i}{\sqrt{2\Pi}\left[\sigma_y(X_n) + H_n - H_i\right] u\, H_n}$$

where Q_i is the release rate of the source giving rise to the i^{th} plume, H_i is the absolute height of the i^{th} plume, and σ_y is the diffusion coefficient. The concentration at time t_n at points nearer the sources than X_n was found by quadratic interpolation using:

$$\chi_p(t_n) = \sum_{i=p+1}^{n} \frac{\chi'_i}{X_i^2} X_p^2 + \sum_{i=1}^{p} \frac{Q_i}{\sqrt{2\Pi}\left[\sigma_y(X_p) + H_n - H_i\right] u H_n} \quad \text{for } p<n$$

Here:

$$H_n = \left[\begin{pmatrix}\text{center line height} \\ \text{of } n^{th} \text{ plume}\end{pmatrix} + 2.15\,\sigma_z(X_n)\right]\left[\;1.1\;\right] = \left[\begin{matrix}\text{height of the } n^{th} \text{ plume} \\ \text{top during the inversion} \\ \text{breakup process}\end{matrix}\right]$$

and:

$$\chi'_i = \frac{Q_i}{\sqrt{2\Pi}\left[\sigma_y(X_i) + H_n - H_i\right] u H_n}$$

where σ_y (X_n) and σ_z (X_n) are calculated according to Carpenter, 1971.

Using the source parameters shown in Tables 9-5-14 through 9-5-17, the maximum concentrations of pollutants, along with their expected time duration, are shown in Table 9-5-22. The predicted fumigation concentrations are less than those estimated by worst case dispersion modeling when the concentrations from a 1-hr fumigation episode are proportioned over the intervals specified by the regulations, e.g., 24-hr for particulates, as was done in the dispersion modeling.

Table 9-5-22

MAXIMUM POLLUTANT CONCENTRATIONS AND THE TIME DURATION FOR EACH AS PREDICTED BY FUMIGATION MODELING, RBOSP

Pollutant	Time from inversion breakup initiation to time of maximum concentration (seconds)	Mixing layer height at maximum concentration (meters)	Distance at which maximum concentration occurs (meters)	Maximum concentration ($\mu g/m^3$)	Integrated concentration of fumigation episode at point of maximum concentration (assumed 1 hour)
Phase I					
SO_2	715	494	1602	10.0	1.53
Particulates	715	494	1602	49.9	9.31
NMHC	715	494	1602	35.2	5.13
Phase II					
SO_2	985	571	2207	79.7	1.74
Particulates	985	571	2207	127	37.1
NMHC	1023	581	2291	43.7	8.93

C. Salt Drift From Cooling Towers - Regulatory emission standards are not applicable to cooling towers, however, potential environmental impact to area biology resulting from salt drift should be considered. Estimation of rate of salt deposition is described below.

Dissolved solids, present in any natural source of water, are concentrated in cooling systems where process heat is removed by evaporation of a portion of the circulating cooling water. Dissolved solids, being nonvolatile, are not carried off with the evaporated water. Concentration of dissolved solids in the cooling system is controlled by the rate of blowdown, a liquid water stream bled from the cooling water system. High rates of blowdown lead to low increases in solids concentration, but result in higher water consumption.

Cooling tower drift results from water droplets (mist), mechanically generated within the tower, being entrained in the exhaust flow and discharged into the atmosphere. In contrast to natural fog droplets, drift droplets contain almost the same concentration of chemicals that are found in the circulating water, and give rise to the phenomenon termed salt drift. A major portion of these drift particles fall out near the tower. The location and amount of fallout depend on wind field, droplet size distribution, and evaporation rates. At any particular time, these factors are related to interactive processes between the cooling tower plume and the existing meteorological conditions. The resulting physical situation is exceedingly complex and hence cannot be modeled by rigorous techniques. The approach taken was to choose two independent approximate techniques, one of which understates and the other of which overstates the actual rate of salt deposition.

The warm, moist air exhausted from the cooling tower contains droplets ranging in size from several microns to several hundred microns. Few measurements of drift deposition from cooling towers have been made, but several which were made at the point of expected maximum deposition reveal the following (Roffman, 1974) under worst case or extreme cases (ambient humidity greater than 90%):

- Without drift eliminators, 1% of the total circulating water is deposited;
- With effective drift eliminators, 0.1% of the total circulating water is deposited.

Below 90% relative humidity, only a portion of the droplets reach the ground, and the remainder of the salt content is effectively dispersed into the atmosphere like gaseous emissions. Estimates of the ground level concentration for the portion of the drift mass which is dispersed can be made, in principal, using diffusion modeling techniques. However, the complex nature of wet plume deposition is not well understood and hence cannot be accurately modeled. Worst case considerations show that most of the drift mass governed by atmospheric dispersion is effectively lost to the atmosphere and this component of deposition is negligible.

The following technique yields very conservative estimates of deposition rates. Recent studies (Winstrom, et al., 1973) on mechanical draft cooling towers have determined droplet size and mass distributions. These distributions were incorporated into a computerized drift trajectory model which took into account fall velocities, meteorological parameters, and droplet size and salinity effects on evaporation rates. Typical results are shown in Figure 9-5-33.

At this time, a conservative estimate of the total salt discharged from the Phase II cooling towers during maximum summertime load operations is 9 g/sec. Over an annual period, the most conservative value is about 7.75 g/sec. The operating parameters for the proposed plant configuration are given in Table 9-5-23. The planned location of the complex lies 150 m almost due north from the main substation for Phase II. An isopleth plot of the expected annual salt deposition rates near the cooling tower using the deposition distribution shown in Figure 9-5-33, weighted by direction as measured by the on site meteorological program, is presented in Figure 9-5-34.

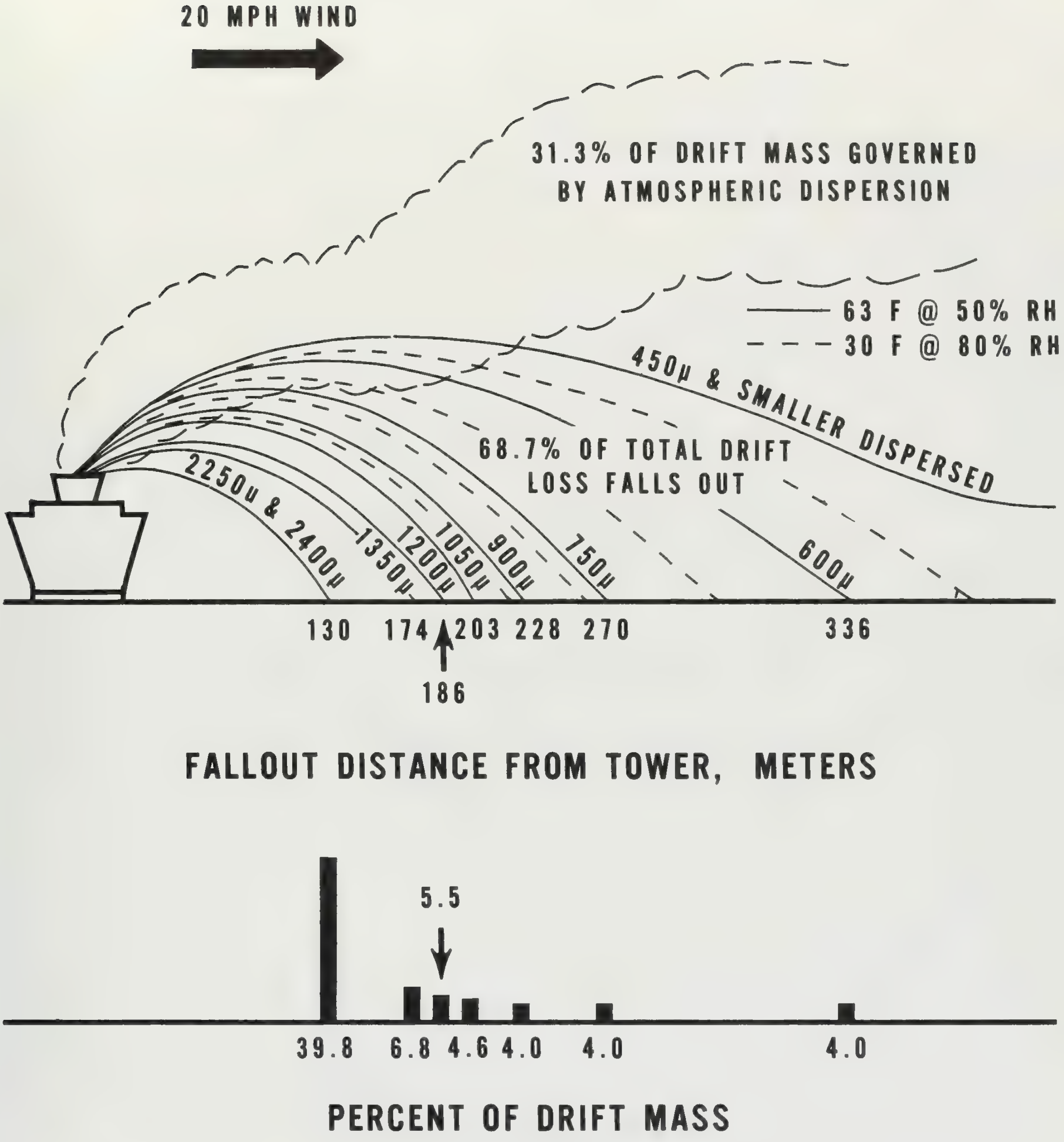


Figure 9-5-33

TYPICAL DROPLET DISPERSION AND FALLOUT FROM COOLING TOWER PLUME

Table 9-5-23

COOLING TOWER OPERATING PARAMETERS AT SUMMERTIME MAXIMUM LOAD (30°C)

	Phase I Stage 1	Phase I Stage 2	Phase II
Total Circulation Rate (m^3/sec)	0.23	0.46	3.25
Total Dissolved Solids (ppm)	1459	1459	1459
Drift Loss (percent)	0.04	0.04	0.04
Number of Cells	1	2	6
Concentration Fraction	4.8	4.8	4.8
Solids Release Rate (g/sec)	0.63	1.26	9.1
Size (meters)	20 x 20	20 x 40	20 x 120

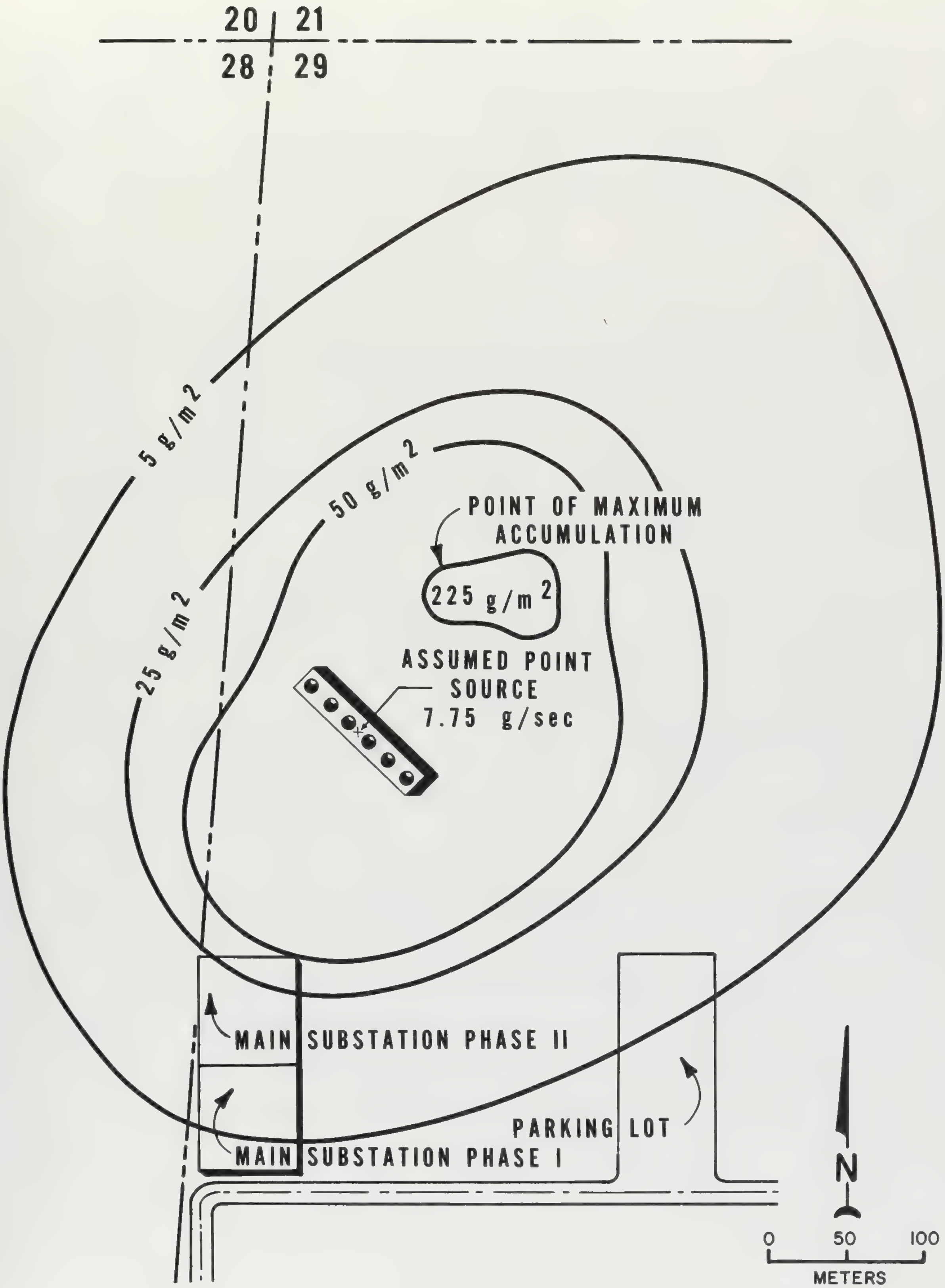


Figure 9-5-34

ISOPLETHS OF ANNUAL SALT DEPOSITION RATE CALCULATED FROM SOLUTION OF THE TRAJECTORY MODEL

Available direction data from the 60-m level of the meteorological tower at Site 1 was used. The cooling tower was treated as a point source for computational purposes, although it will be built with its short axis oriented along a NE-SW line (prevailing wind direction). The point of maximum rate of accumulation is about 150 m northwest of the cooling tower where salt is predicted to build up (in the absence of other considerations such as precipitation) at about 225 g/m^2 over an annual period.

Another recent analytical study (Roffman, 1973) incorporated a relatively general solution to the diffusion equation to predict salt drift deposition rates. The Roffman technique yields a less conservative estimate of salt deposition rates. In addition, the solution considered plume rise effects including the buoyancy of the wet plume. A plot of the expected annual salt deposition accumulation along the northeast radial for the mechanical drift cooling tower is shown in Figure 9-5-35.

The most obvious differences between the diffusion equation model and the trajectory model (Figure 9-5-34) are the magnitude of the deposition rate and the distance downwind to the point of maximum accumulation rate. These two computational schemes represent the least and most conservative techniques available for estimation of cooling tower drift deposition. The true physical picture most probably lies somewhere between these two extremes.

In addition to the cooling tower supply water saline content, corrosion inhibiting materials will be added to the circulating cooling water. It is anticipated that 10 ppm of chromium, as CrO_4, and 4 ppm of zinc, as $ZnCl_2$, will be present in the cooling tower drift. These estimates result in a maximum release rate of less than 0.018 g/sec of these materials. Linear interpolation of the results shown in Figure 9-5-34 gives a worst case deposition rate of 0.52 g/m^2 over an annual period.

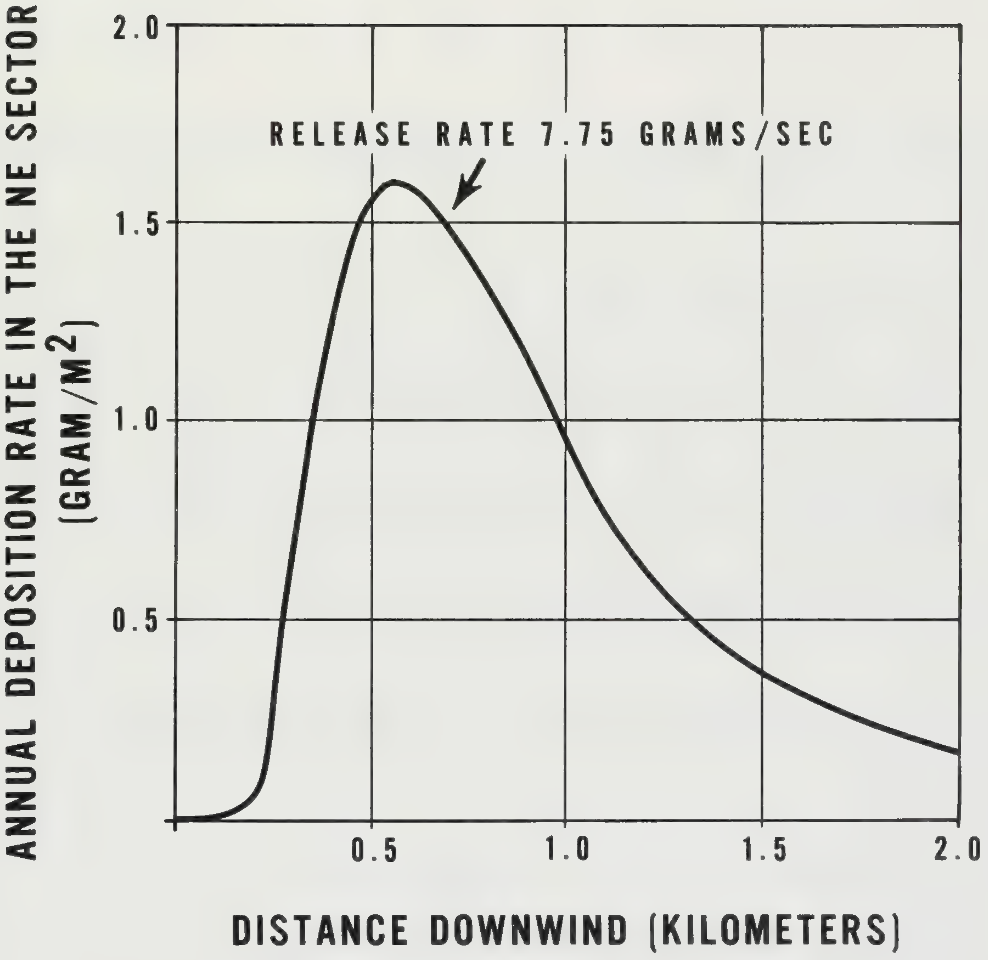


Figure 9-5-35

ANNUAL DEPOSITION RATE VERSUS DIAMETER ALONG THE NE SECTOR. CALCULATED FROM ANALYTICAL SOLUTION TO DIFFUSION EQUATION.

5.8 APPLICABLE REGULATIONS

The development of the oil shale resource will affect many individuals, organizations, and local communities and county, State and Federal governments. The orderly development of this resource calls for compliance with many public health and air quality regulations. The most prominent of these regulations and agencies are listed below.

A. Tract C-a Oil Shale Lease - Environmental Stipulations and References.

B. National Environmental Policy Act of 1969 and the Environmental Protection Agency, Public Law 91-190, January 1, 1970.

- The Federal Clean Air Act:
  42 U.S. Code 1857-18571, Public Law 91-604, 84 Stat. 1676.
- National Ambient Air Quality Standards:
  Federal Register, Vol. 36, No. 67, April 6, 1971.
- Standards of Performance for New Stationary Sources:
  Federal Register, Vol. 36, No. 247, December 23, 1971.
- Prevention of Significant Air Quality Deterioration:
  Federal Register, Vol. 39, No. 235, December 5, 1974.

C. The Occupational Safety and Health Act of 1970, Public Law 91-596, S.2193, December 29, 1970.

- OSHA, Construction and Health Regulations:
  Federal Register, June 27, 1974, Part II.
- OSHA, Occupational Safety and Health Standards:
  Federal Register, June 27, 1974, Part II.
- MESA, Memorandum of Understanding Between MESA and OSHA:
  Federal Register, July 26, 1974.

D. Mining Enforcement and Safety Administration (MESA)

- MESA, Mine Standards:
  United States Department of the Interior, March 1974.

- Federal Metal and Nonmetallic Mine Safety Act of 1966:
  Public Law 89-577, H.R. 8989, September 16, 1966.
- Open Pit Mines:
  30 CFR Part 56.
- Sand, Gravel and Crushed Stone Operations:
  30 CFR Part 57.
- Underground Mines:
  30 CFR Part 57.

E. State of Colorado Air Pollution Control Act of 1970, Chapter 66, Article 31.

- Regulation No. 1 - Emission Control Regulations for Particulates, Smokes, and Sulfur Oxides for the State of Colorado.
- Regulation No. 2 - Odor Emission Regulations.
- Regulation No. 3 - Regulation Governing Authority to Construct and Permit to Operate.
- Regulation No. 6 - Standards of Performance for New Stationary Sources.
- Regulation No. 7 - Regulation to Control the Emissions of Hydrocarbon Vapors.
- Regulation No. 9 - Regulation to Control Emissions to Chemical Substances and Physical Agents.
- Ambient Air Standards for Metropolitan Denver, Air Quality Control Areas and the State of Colorado.

F. Colorado Mining Laws with Safety and Healty Regulations, Bulletin 20, Colorado Bueau of Mines, Denver, Colorado, January 1, 1971.

G. Colorado Department of Labor and Colorado Occupational Safety and Health (COSH).

5.9 DEFINITIONS

The following terms have been used in the text or in various regulations and are defined here to assist the reader to a clear understanding of the Air Quality Control Plan.

Air Contaminant - any fume, smoke, particulate matter, vapor, gas, or any combination thereof, but not including water vapor or steam condensate.

Air Contamination Source - any source whatsoever at, from, or by reason of which there is emitted or discharged into the atmosphere any air contaminant.

Air Pollution - any concentration of one or more air contaminants in the outdoor atmosphere as has caused, is causing, or if unabated may cause injury to human, plant, or animal life, or injury to property, or which unreasonably interferes with the comfortable enjoyment of life or property or with the conduct of business.

Ambient Air - is the surrounding outside air.

Atmosphere - means the air that envelops or surrounds the earth. For the purpose of this regulation emissions of air contaminants from a building or structure not specifically designed to control air pollution originating from an air contamination source or sources within such building or structure shall constitute an emission to the atmosphere.

Bagfilter - a filtering apparatus with porous cloth or felt bags through which dust laden gases are sent, leaving the dust on the inner surfaces of the bags.

Baghouse - the large chamber or room and associated equipment for holding and operating bagfilters used to filter dust laden air or gas streams.

Emission - the discharge or release into the atmosphere of one or more air contaminats.

Emission Control Regulation - any standard promulgated by regulation which is applicable to all air contamination sources within a specified area and which prohibits or establishes permissible limits for specific types of emissions in such area, and also any regulation which by its terms is applicable to a specified type of facility, process, or activity for the purpose of controlling the extent, degree, or nature of contamination emitted from such type of facility, process, activity, and also any regulation adopted for the purpose of preventing or minimizing emission of any air contaminant in potentially dangerous quantities.

Fuel Burning Equipment - any furnace, boiler apparatus, stack, or appurtenances thereto used in the process of burning fuel for the primary purpose of producing heat or power by indirect heat transfer.

Fugitive Dust - solid airborne particulate matter emitted from any source other than an opening which channels the flow or air contaminants and then exhausts the contaminants directly into the atmosphere. Fugitive dust also includes solid particles released into the atmosphere by natural forces or by mechanical processes such as crushing, grinding, milling, drilling, demolishing, shoveling, conveying, covering, bagging, sweeping, etc.

National Primary Standard - National Primary Ambient Air Quality Standards define levels of air quality which the EPA Administrator judges are necessary, with an adequate margin of safety, to protect the public health.

National Secondary Standard - National Secondary Ambient Air Quality Standares define levels of air quality which the EPA Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

Opacity - the degree to which an air contaminant emission obscures the view of an observer, expressed in percentage of the obscuration, or in the degree (percent) to which transmittance of light is reduced by an air contaminant emission.

Open Burning - fire, where any material is burned in the open or in a receptacle other than a furnace, incinerator, or other equipment connected to a stack or chimney.

Opening - any single chimney, conduit, duct, smokestack, flue or other contrivance from which air contaminants are exhaused into the atmosphere.

Palliative - A solution or material applied to roads or land surfaces to prevent the formation of dust due to use or traffic.

Particulate Matter - any material, except uncombined water, that exists in a finely divided form as a liquid or solid.

Petroleum Distillate - any finished and intermediate products which are manufactured in crude petroleum processing and finishing operations having a vapor pressure of 1.5 psia or greater including gasoline manufactured from any source or by using any process.

Process or Process Equipment - any action, operation, or treatment, involving chemical, industrial, or manufacturing factors, such as furnaces, by-product coke plants, heating and reheating furnaces, kilns, dryers, roasters, and equipment used in connection therewith, and all other methods or forms of manufacturing or processing that may emit air contamination.

Process Unit - any single process or process equipment.

Process Weight - the total weight of all materials introduced into a source operation, which source causes any discharge of air contaminants into the atmosphere. Solid fuels introduced into any specific source will be considered as part of the process weight, but liquid and gaseous fuels and combustion air will not.

Process Weight Rate - a rate established as follows:

- for continuous source operations, the total process weight for the entire period of continuous operation or for a typical portion thereof, divided by the number of hours of such period or portion thereof, or
- for cyclical or batch unit operations, or unit processes, the total process weight for a period that covers a complete operation or an integral number of cycles, divided by the hours of actual process operation during such a period, or
- for operations, not specified above, determine the process weight that results in a minimum value for allowable emissions.

Retardant - a material that inhibits the movement of soil particles and tends to bind them together in a crust like formation. Examples are polymers latex, or other cohesive binder.

Smoke - small gas borne particles resulting from incomplete combustion, consisting predominantly, but not exclusively, or carbon and other combustible material.

Stack or Chimney - any vertical flue, conduit, or duct arranged to conduct an effluent to the open air.

Standard Conditions - a gas temperature of 68 degrees Fahrenheit and a gas pressure of 29.92 inches of mercury.

Stationary Source - any building, structure, facility, or installation which emits or may emit any air pollutant.

Suppression - the means of controlling or allaying dust by the use of water or wetting agents.

Surfactant - is an acronym meaning surface-active-agent which is a soluble compound that reduces the surface tension of liquids, or reduces interfacial tension between two liquids or a liquid and a solid such as a detergent, soap solution, or wetting agent.

Upset Conditions - an unpredictable equipment failure or other malfunction which results in the violation of emission control regulation, and which is not due to improper or careless operation.

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CHAPTER 6

WATER QUALITY CONTROL

CHAPTER 6

WATER QUALITY CONTROL

The water quality control plan to be employed in developing Tract C-a is illustrated schematically in Figure 9-6-1. The system is an adaptation of the American Petroleum Institute's zero discharge water concept. In RBOSP's case, all water is planned to be consumptively used, either through evaporation to the atmosphere or by absorption in the processed shale disposal pile where it will be an aid to achieving optimum compaction.

The system will be designed to control surface runoff water as well as mine and processing waste waters. Surface water originating outside the Tract C-a project area will be diverted around RBOSP facilities. Surface water originating within the project area will be controlled by a series of ditches and retention dams and either recycled to RBOSP's water supply system or allowed to evaporate.

From a water control standpoint, RBOSP's processing facility will be closely akin to typical U. S. refineries. Refinery operators are now quite experienced in controlling water quality, and application of the zero discharge concept in a shale oil processing facility will be a relatively small step from conventional refinery practice. The other principal source of poor quality water in the Rio Blanco Oil Shale complex is the mine. In this respect, however, RBOSP will be able to not only control mine water but to put it to beneficial use as well. Water developed in the mine dewatering operation will be of sufficient quality to permit its use in all project activities. Some water will be treated to provide potable water supplies where needed, but most of the ground water from beneath Tract C-a will be used as is.

Current information indicates that ground water from mine dewatering must be supplemented during Phase I and the early years of Phase II by additional ground water wells to meet RBOSP demands. All mine water produced during this period will thus become part of the project's water supply and be completely

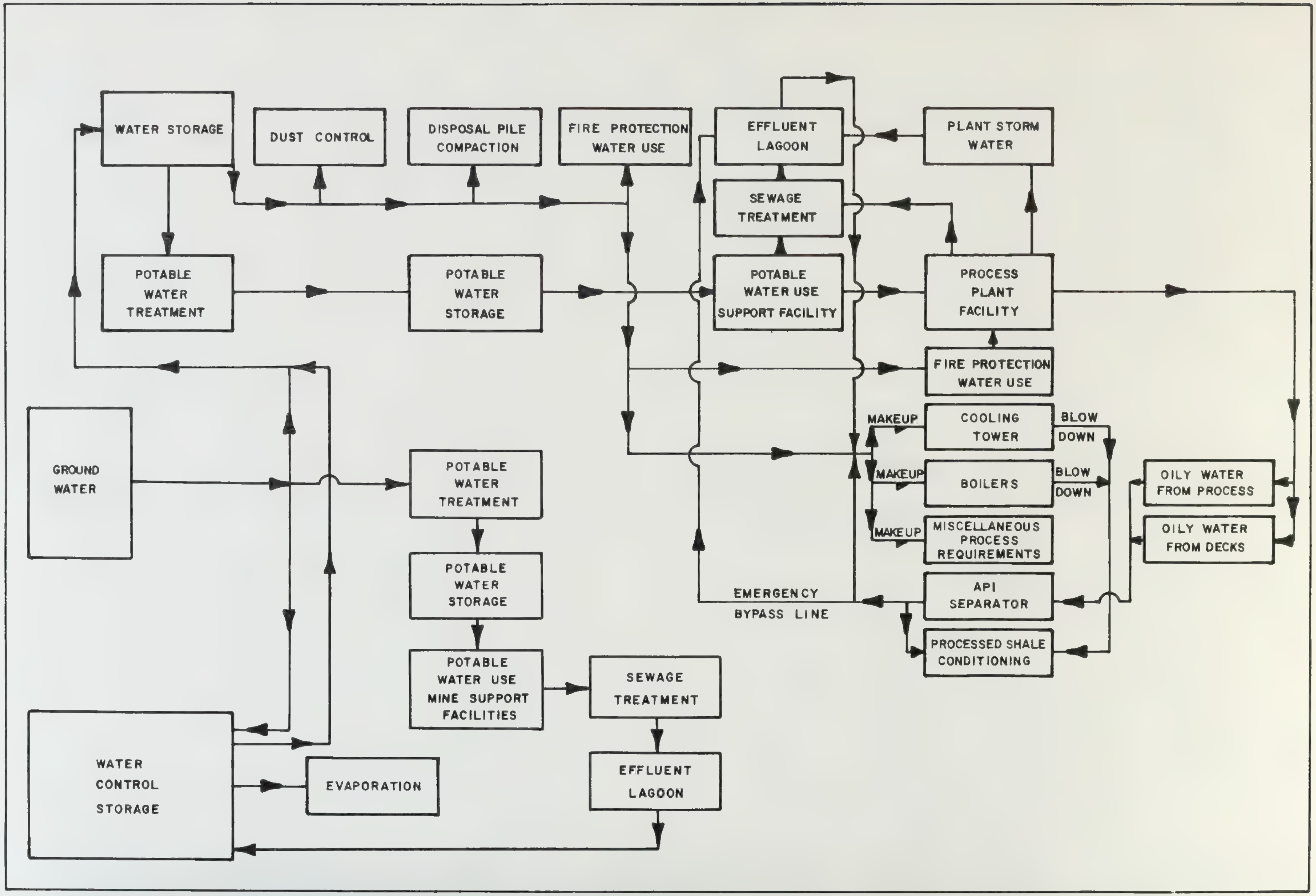


Figure 9-6-1

RBOSP WATER QUALITY CONTROL SYSTEM

controlled by virtue of the zero discharge water handling system. Beginning about the eighth or ninth year of Phase II, mine dewatering is expected to exceed project needs but exact quantities are difficult to predict at this time.

After mining begins, mine dewatering operations must continue essentially uninterrupted whether the processing facility is operating or not. Before the time when mine water is expected to exceed project demand, a small water collection pond will be provided near the processing facility. It will be used to store water from dewatering operations when the processing facility is either shut down or operating at reduced capacity; the supplementary water wells expected to be needed during this time can also be used to regulate water production.

When water from dewatering operations begins to exceed project demand, a larger water control reservoir located about three miles east of the tract in Corral Gulch will be used to store excess mine water. As now planned, therefore, the Corral Gulch reservoir will not be constructed until after Phase II begins.

Despite the ground water information developed to date by RBOSP, actual mine dewatering requirements will not be known until mining operations begin. Thus, the possibility does exist that mine water production could exceed RBOSP demand earlier than expected. This possibility is viewed as remote, but in the event that excess mine water is encountered earlier than expected, RBOSP will consider two alternatives for handling the water: (1) the excess water will be used to augment flow in area streams, or (2) the Corral Gulch water control reservoir will be built earlier than now planned and will be used to store the excess water.

If shale oil production is increased beyond the Phase II level of 55,800 BPSD, a surface water supply will have to be developed to supplement Tract C-a ground water resources. Should this occur, however, it will not change the modified zero water discharge plan; part of the water supply will merely be coming from a different source. For a more complete description of RBOSP's water supply plan, see Section 8, Chapter 5. The quality of existing surface and ground water resources in the vicinity of Tract C-a is described in detail in Section 3, Chapters 4 (Hydrology) and 8 (Aquatic Ecology).

6.1 ZERO DISCHARGE WATER HANDLING

The zero discharge technique was developed by the American Petroleum Institute to help U. S. refineries reduce their water consumption. An added benefit of the system is that energy use is also reduced.

Figure 9-6-2 is a schematic comparison of typical conventional and zero discharge water handling. The zero discharge system is represented by the dashed line and changes from the conventional system by the small dotted line; solid lines are common to both systems. Zero discharge differs from conventional water handling in several respects. For example, rainfall runoff is collected throughout the plant area with a conventional storm sewer system, but instead of sending the water directly to the API separator and then discharging it to a natural water course as in a conventional system, the water is collected, stored, then pumped to cooling towers. Another difference is that more cycles of concentration are used in cooling towers to minimize blowdown.

The zero discharge water concept is easily adaptable to the Rio Blanco Oil Shale Project because waste treating, concentration drying and solid waste disposal as shown on Figure 9-6-2 will not be required. Instead, water from the API separator will be used for moisturizing processed shale as it leaves the oil shale retorts. Some of this water will also be used to control dust on and irrigate newly-revegetated portions of the processed shale and overburden disposal pile.

6.2 WATER CONTROL ON TRACT C-a

The following paragraphs give a more detailed description of the flow and final disposition of water within and around RBOSP facilities. Figure 9-6-3 shows the general location of water control facilities that are referenced in

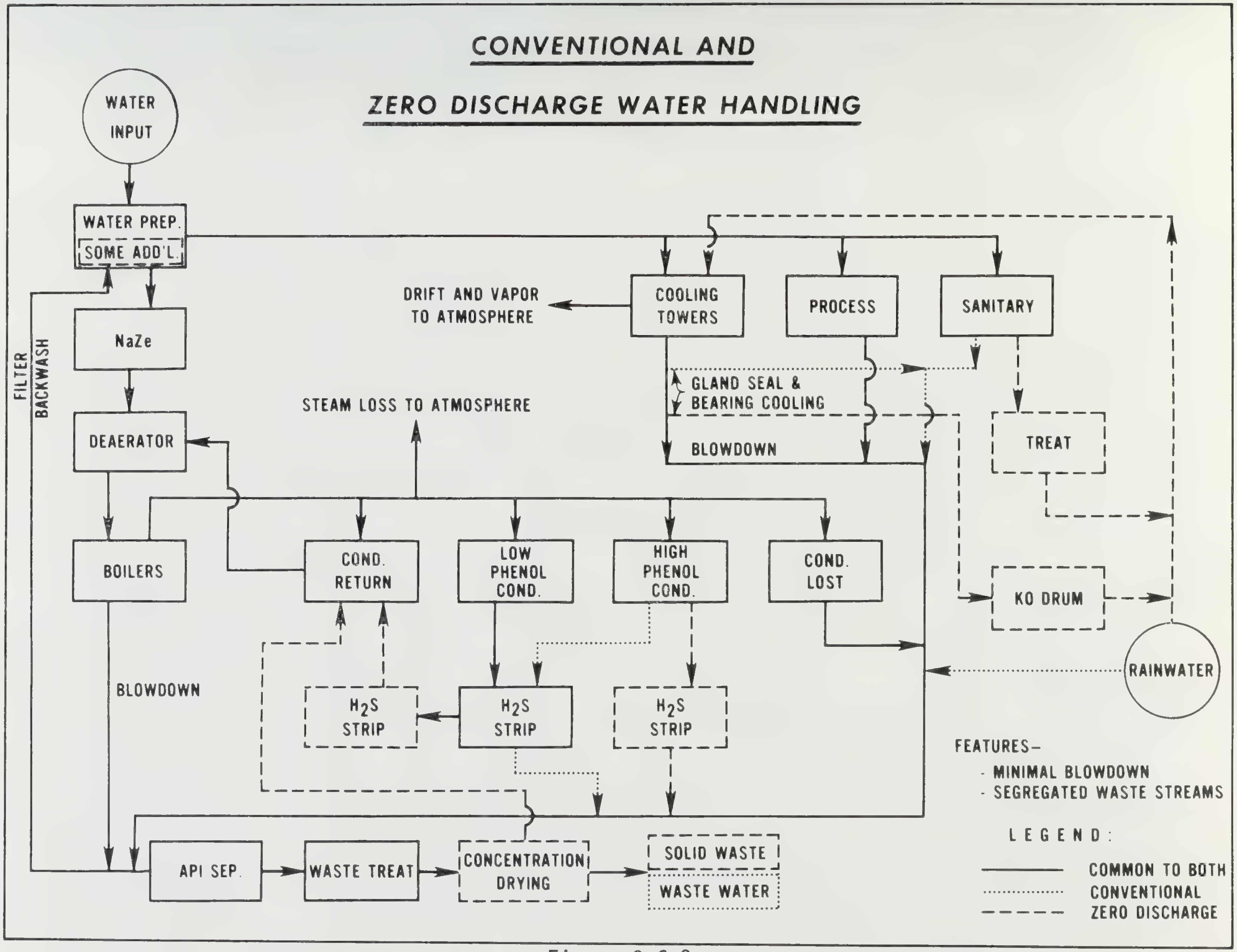


Figure 9-6-2

CONVENTIONAL AND ZERO DISCHARGE WATER HANDLING

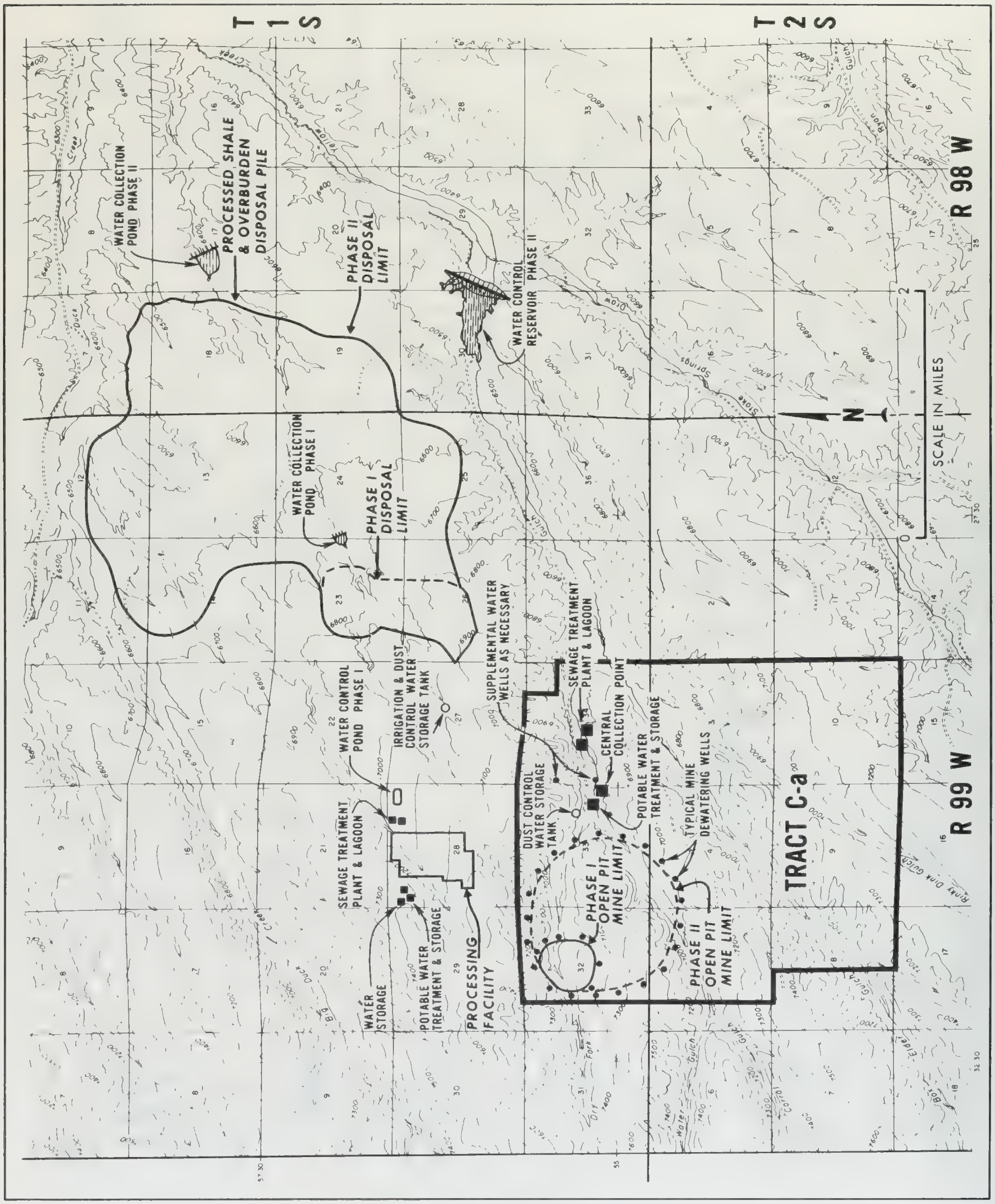

T 1 S
T 2 S
R 99 W
R 98 W
WATER COLLECTION POND PHASE II
PROCESSED SHALE & OVERBURDEN DISPOSAL PILE
PHASE II DISPOSAL LIMIT
WATER CONTROL RESERVOIR PHASE II
WATER COLLECTION POND PHASE I
PHASE I DISPOSAL LIMIT
WATER CONTROL POND PHASE I
IRRIGATION & DUST CONTROL WATER STORAGE TANK
SUPPLEMENTAL WATER WELLS AS NECESSARY
SEWAGE TREATMENT PLANT & LAGOON
CENTRAL COLLECTION POINT
POTABLE WATER TREATMENT & STORAGE
TYPICAL MINE DEWATERING WELLS
DUST CONTROL WATER STORAGE TANK
SEWAGE TREATMENT PLANT & LAGOON
PHASE I OPEN PIT MINE LIMIT
PHASE II OPEN PIT MINE LIMIT
WATER STORAGE
POTABLE WATER TREATMENT & STORAGE
PROCESSING FACILITY
TRACT C-a
N
0
2
SCALE IN MILES
Duck Creek
Stake Springs
Ryan Gulch
Dry Fork
Corral Gulch
Water Gulch
Box Elder Gulch
Rinky Dink Gulch

Figure 9-6-3

the following discussion. Reference to Figure 9-6-1 on page 9-6-2 is also helpful when reading the following descriptions.

Precise amounts of water flowing throughout the RBOSP system are not predictable with currently available information; however, the final disposition under average Phase II operating conditions is estimated to be as follows:

	%
Evaporation	50
Processed shale moisturizing	32
Chemically converted in processing	3
Dust control	9
Irrigation	5
Potable consumption and miscellaneous	1
	100

Sources of evaporation are cooling towers, retort scrubbers, collection ponds, storage reservoirs and effluent lagoons. Most of the water used for dust control and irrigation on the surface of the processed shale and overburden disposal pile will either evaporate or be absorbed by the processed shale and overburden. The pile itself will be constructed to be impervious which will prevent saturation and the associated migration of leachate through the pile. Most of the relatively minor amounts of water used for dust control on roads and other areas in the project complex will evaporate.

A. Mine - As noted above and described in more detail in Section 8, Chapter 5, ground water from mine dewatering will be the principal source of water supply for RBOSP needs through Phase II production rates; thus, the most significant potential source of surface water pollution from the mine is controlled by using mine discharge as a water supply. Surface runoff into the open pit and mine seepage are the other sources of contaminated water in the mine; these will be collected at the bottom of the pit by a sump and, together with water from the mine dewatering wells ringing the perimeter of the pit, will be delivered to a central collection point east of the pit. During Phase I and the early years of Phase II, water from supplementary wells will also be conveyed to the central collection point.

Three water lines will normally leave the central collection point: one will go to a nearby storage tank for dust control in the mine area and on haul and access roads; a second will go to the processing facility; the third will go to a potable treatment plant to provide potable water for the mine support buildings. During periods when the processing plant is either shut down or operating at less than full capacity or when excess mine water is being produced, a fourth stream will leave the collection point and be conveyed to either an appropriately sized water control reservoir in Corral Gulch or to a small water control pond near the processing facility. Water from these storage facilities will either be recycled to the water supply system or be allowed to evaporate.

A sewage treatment plant and effluent lagoon will be provided near the mine support buildings to provide control of surface runoff and sanitary waste water.

B. Processing Facility - The water stream from the central collection point to the processing facility goes first to a storage pond from which dust control, irrigation, and fire protection water in addition to processing water is withdrawn. Part of the water from the storage pond goes to a potable water treatment plant to provide potable needs in the processing facility and nearby support facilities, including the administration building and warehouses.

In the processing facility, waste water streams are: blowdown from cooling towers and boilers, water condensed in the retorting and upgrading steps, and surface runoff. The surface runoff is collected in a conventional storm sewer system and conveyed to an effluent lagoon. Boiler and cooling tower blowdown is used for moisturizing processed shale.

Water condensed from processing units is sent to an API separator system consisting of a surge pond, API separator and retention pond. Clear water from the retention pond is sent to processed shale moisturizing boilers, or cooling towers. An emergency bypass line to the effluent lagoon will be provided to handle water from the API separator in case of a processing facility upset. The API separator system is described in more detail in Section 6.

A sewage treatment plant near the processing facility will handle waste water from processing and nearby support buildings. The sewage treatment plant will discharge into the effluent lagoon; the effluent will either be recycled to cooling towers and boilers or be allowed to evaporate.

During Phase I and the early years of Phase II, a small water control pond will be provided near the northeast corner of the processing facility to which water from mine dewatering will be conveyed during periods when the processing facility is either shut down or operating at reduced capacity. The water control reservoir in Corral Gulch will serve this function after the first few years of Phase II operations and won't be installed until then.

C. Processed Shale and Overburden Disposal Pile - The sources of contaminated water from the disposal pile are surface runoff and, possibly, processed shale leachate. As will be discussed later, runoff originating outside the disposal area will be diverted around and discharged to a drainage downstream of the pile; this system will be continually modified as the pile grows larger.

Surface runoff from the pile will be collected by a series of lined ditches around the perimeter of the pile then conveyed to a lined collection pond at the northeast edge of the pile. The water in the collection pond will either evaporate or be returned to the pile for dust control and/or irrigation, depending on needs.

Construction of the disposal pile is described in Section 7 of the DDP. It will be constructed to preclude or minimize the discharge of leachate by surrounding the main body of processed shale on all sides with an impermeable layer of highly compacted processed shale; however, in the event that some leachate is discharged, it too will be conveyed to the lined collection pond mentioned above.

D. General Storm Drainage Control - A general storm drainage system will be developed with the following criteria in mind:

- Surface water originating outside the RBOSP project area will be diverted around all project facilities so that none of it enters the internal project drainage system.
- Surface water originating within the project area will be controlled to prevent discharge to surface streams outside the area, except in those areas where the quality of runoff water is sufficient to permit such discharge.

The storm drainage system will be continually modified as project activities expand and production increases. During Phase I, for example, a relatively modest diversion system will be required to convey water from Dry Fork around the mine and into Corral Gulch. As production increases and the pit expands, the diversion system will also be expanded until it will eventually be necessary to divert drainage from Dry Fork, Water Gulch, and Corral Gulch into Box Elder Gulch.

Similarly, surface runoff in the vicinity of the processed shale and overburden disposal pile will be controlled by a system that is continually modified and expanded.

Diversion ditches throughout the project complex, including those around the processed shale and overburden disposal pile, will be sized to accommodate at least the peak flow expected from a short duration, 100-year storm; collection ponds and reservoirs will be sized to hold at least six hours of runoff from a 100-year storm. All calculations used for predicting such peak flows and storage requirements will be based on methods used by the Soil Conservation Service, U. S. Department of Agriculture.

Effluent lagoons will be lined with impermeable material as will the water collection pond, and ditches feeding it from around the processed shale and overburden disposal pile. Most other ponds, reservoirs and ditches probably will not be lined unless further investigation indicates that it will be necessary.

Dams creating ponds or reservoirs will be constructed in accordance with standards and specifications approved by the Colorado State Engineer and the AOSS. Materials native to the region will be used wherever feasible. Cores of dams will be constructed of impervious materials.

E. Summary - In effect, RBOSP will control water quality during Tract C-a development by controlling water flows and not permitting low-quality water to be discharged to area surface streams or to ground water aquifers. To ensure that the system is effective, a water monitoring program will be conducted; it is described in Section 11.

In addition to the water control system described in this chapter, RBOSP will implement other control systems that will also serve to prevent water pollution. The control of oil and other hazardous materials, including the spill contingency plan for the product pipeline from Tract C-a to Rangely, is described in Section 9, Chapter 7. Construction and operation of the processed shale and overburden disposal pile is the subject of Section 7. The control and disposition of other solid wastes, including processing catalysts, is described in Section 9, Chapter 9.

CHAPTER 7

OIL AND HAZARDOUS MATERIAL CONTROL

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 7

OIL AND HAZARDOUS MATERIAL CONTROL

The Oil and Hazardous Material Control Plan has been formulated recognizing that the best control plan is prevention of spills through proper design of storage, handling and transporting facilities. However, a spill contingency plan will be implemented during all phases of the project establishing procedures to be followed to minimize damages in the event of accidental spills.

This spill contingency plan includes procedures for notification, containment, repair and cleanup of spills. The primary objective is to minimize, as far as practicable, any damage from an oil spill to persons, property, flora and fauna.

7.1 APPLICABLE REGULATIONS

Facility design and contingency planning have been developed in conformance with the applicable regulations, codes and standards. Principal regulations follow:

- U.S. Department of the Interior, Oil Shale Lease Tract C-a, February 5, 1974
- Title 49, Chapter 1, Part 195, Transportation of Liquids by Pipeline, Department of Transportation
- Title 40, Chapter 1, Part 165, Federal Register (FR) 39, No. 85, May 1, 1974, Regulations for the Acceptance of Certain Pesticides and Recommended Procedures for the Disposal and Storage of Pesticides and Pesticide Containers.
- Title 40, Chapter 1, Part 112, FR 38, No. 237, December 11, 1973, Oil Pollution Prevention (Nontransportation-Related Onshore and Offshore Facilities).
- Title 40, Chapter V, Part 1510, FR Vol. 40, No. 28, February 10, 1975, National Oil and Hazardous Substances Pollution Contingency Plan.

- PL 92-500, Federal Water Pollution Control Act Amendments of 1972.
- Colorado Revised Statutes (1973) 25-8-601 - Requires Notification of Spillage to Colorado Department of Health.
- Colorado Senate Bill No. 390, Water Quality Control.
- Colorado Health Department - Procedures and Directory for Reporting Spills of Oil and Hazardous Materials.

7.2 STORAGE AND HANDLING

A. Storage - The facilities for storage of large quantities of product oil; other hydrocarbon products; diesel fuel; by-product sulfur and ammonia; and any other chemicals will be designed to minimize the possibility of spillage. The layout and construction of the tanks, valves, piping and appurtenances will follow the requirements of the Tract C-a lease and recommendations and standards of the American Petroleum Institute (API).

Tanks will be enclosed by dikes designed to form spill-containment basins. Interior surfaces of the dikes areas will be impermeable. The diked areas will be large enough to contain 150% of the volume of the tank(s) enclosed plus the volume of trapped precipitation that might be impounded at the time of a spill.

Each area will be designed for drainage away from the tanks into a gathering basin. The drainage from these diked areas will enter the process facility storm drainage system and pass through an API oil separator. The reclaimed water will then be used to cool and moisturize processed shale. Any oil present will be removed from the water and returned to the oil handling system.

Catchments will be constructed in any natural drainageways immediately downhill from the oil storage facilities so that should oil find its way outside the containment facilities, it can easily be controlled before it reaches a water course.

B. Handling of Pesticides - Insecticides, rodenticides and herbicides are often used on construction sites to increase health and safety, maintain a pleasant environment and reduce maintenance and fire hazards. Rodents are often attracted to construction sites, necessitating the use of dangerous rodenticides.

Herbicides, rodenticides and pesticides are not contemplated for general use on the project, and their use will require prior approval of the Area Oil Shale Supervisor. Clearance for use of many of these chemicals is also required by restrictive Federal, State and local regulations.

If the need for use should arise, an awareness of the need to adhere to recommended dosages, type of application equipment, time of application, cleaning of application equipment and safe disposal of these chemicals will be instilled in employees and contractors engaged in these activities. The disposal and storage of pesticides and pesticide containers will conform to recommendations set forth in applicable Federal, State and local laws and regulations and the procedures promulgated recently by the Environmental Protection Agency.

7.3 SPILL CONTINGENCY

The following are guidelines designed to provide procedures and assistance in the preparation of detailed spill contingency response plans. The alerting and action flow procedure will conform in general to Figure 9-7-1, although some of the titles of various jobs descriptions may change when the organizational structure for the project is finalized.

A. Nontransportation - Related Facilities

1. Discovery and System Shutdown - The detection of leaks, overflows and miscellaneous spillage will be a part of the standard operating and maintenance procedures for the project. To the extent practical, automatic controls will be installed on all units that will operate in a fail safe manner thereby minimizing dependence on the human element. Indicating, recording, and controlling devices monitoring pressures, temperatures, and flow rates will be integrated with all processing equipment. In addition, alarms and shutdowns

systems will be used to warn of unusual process conditions and shut down operation before equipment failure can occur. Visual inspection of all equipment will be on a routine scheduled basis.

2. Notification - When a spill is observed, alerting actions and reporting procedures will immediately be set in motion. The reporting procedure and level of authority to be notified will depend on the magnitude and sensitivity of the area of occurrence.

a. Reporting to Federal and State Agencies - Federal and Colorado regulations require immediate reporting of spills that enter streams or could pollute either surface or ground water. Once the maintenance superintendent has confirmed the occurrence of a reported spill and action has been initiated to control the spill, the following agencies will be notified:

- Area Oil Shale Supervisor, U. S. Geological Survey, Grand Junction, Colorado
- Region VIII, Office of EPA, Denver, Colorado
- Colorado Department of Health, Denver, Colorado
- Bureau of Land Management, Craig, Colorado

b. Internal Reporting - Regulations set a definite procedure for external notification. However, internal reporting can vary with the size of spill and significance of response requirements. Due to the number of people to be notified and the need for simultaneous initiation of response action by local supervisors, delegation of alerting duties is required. This progressive alerting and action procedures is demonstrated on Figure 9-7-1.

3. Information Gathering - Certain information pertinent to planning the response to a spill occurrence must be gathered from the reporting source. This information is generally covered in the following listing:

- Material spilled.
- The time a spill started or was first observed.
- The location where the spill occurred and the present estimated spread rate.

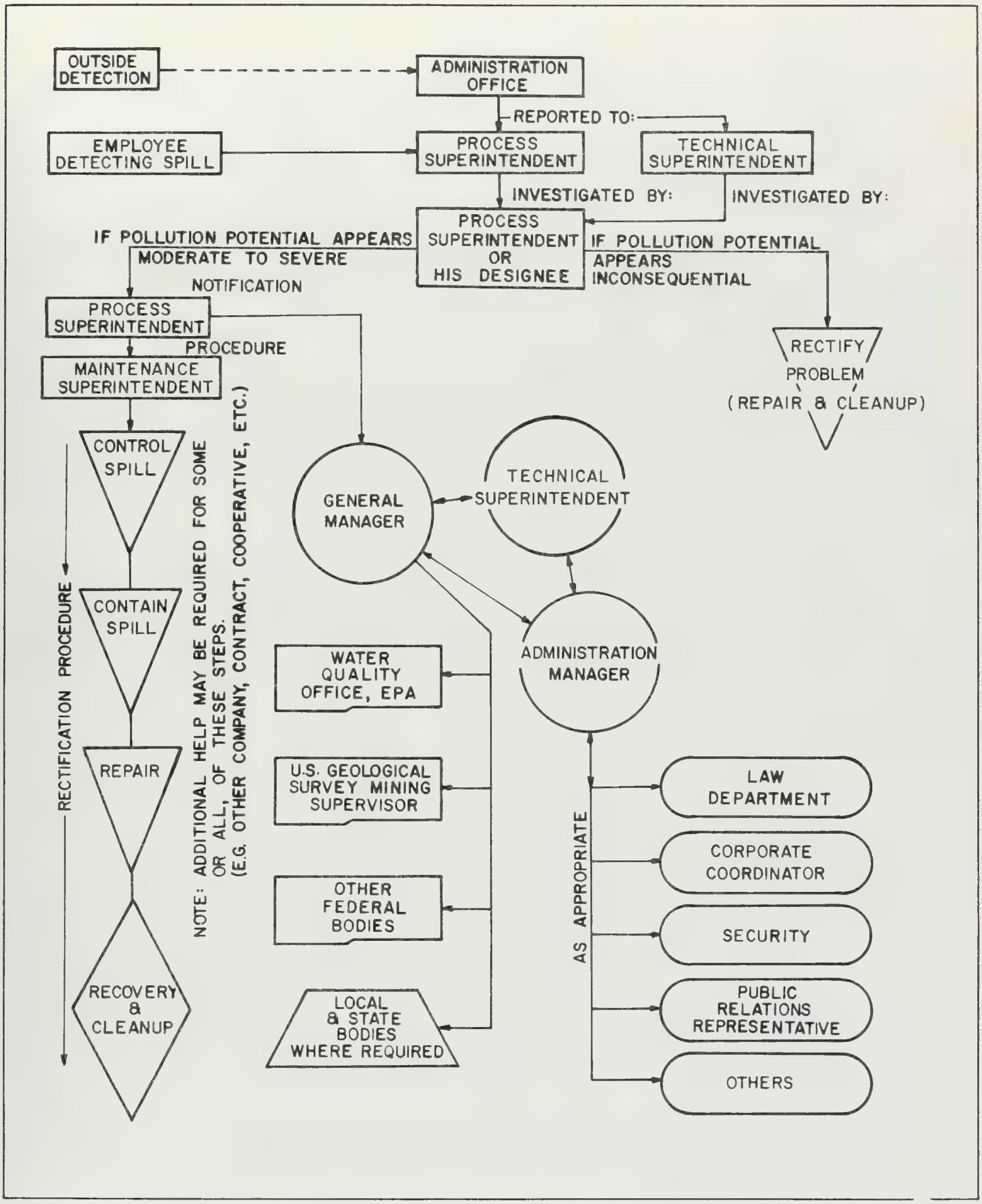

OUTSIDE DETECTION
ADMINISTRATION OFFICE
REPORTED TO:
EMPLOYEE DETECTING SPILL
PROCESS SUPERINTENDENT
TECHNICAL SUPERINTENDENT
INVESTIGATED BY:
INVESTIGATED BY:
PROCESS SUPERINTENDENT OR HIS DESIGNEE
IF POLLUTION POTENTIAL APPEARS MODERATE TO SEVERE
IF POLLUTION POTENTIAL APPEARS INCONSEQUENTIAL
NOTIFICATION
PROCESS SUPERINTENDENT
PROCEDURE
MAINTENANCE SUPERINTENDENT
RECTIFY PROBLEM (REPAIR & CLEANUP)
CONTROL SPILL
CONTAIN SPILL
REPAIR
RECOVERY & CLEANUP
RECTIFICATION PROCEDURE
NOTE: ADDITIONAL HELP MAY BE REQUIRED FOR SOME OR ALL, OF THESE STEPS. (E.G. OTHER COMPANY, CONTRACT, COOPERATIVE, ETC.)
GENERAL MANAGER
TECHNICAL SUPERINTENDENT
ADMINISTRATION MANAGER
WATER QUALITY OFFICE, EPA
U.S. GEOLOGICAL SURVEY MINING SUPERVISOR
OTHER FEDERAL BODIES
LOCAL & STATE BODIES WHERE REQUIRED
AS APPROPRIATE
LAW DEPARTMENT
CORPORATE COORDINATOR
SECURITY
PUBLIC RELATIONS REPRESENTATIVE
OTHERS

Figure 9-7-1

ALERTING AND ACTION PROCEDURE

- An estimate of the amount spilled or rate of release if the spill is continuing.
- The environmental conditions, including temperature, wind direction and speed.
- A description of the area likely to be affected, such as water sources and wildlife areas.
- The circumstances leading to the spill.
- The action being taken to respond to the spill and by whom.
- The agencies or other persons already notified.

4. Manpower, Equipment and Material Availability - The contingency plan will provide listings of manpower, equipment and material availability from project sources and from outside contractors, other companies in the area and the parent companies as applicable.

5. Containment - Except where preconstructed diking systems are provided, men, equipment and supplies will have to be transported to the scene of the spill as quickly as possible to implement containment procedures. Although each spill will call for individual techniques, the general methods described below are applicable:

- Source control - This involves the closing of valves and shutting down of equipment and immediate repair of damaged facilities or those causing leaks even if temporary.
- Spread control - Control to keep spill from spreading outside an area of containment can be effected by: construction of dikes and diversion ditches; spreading of absorbents; or use of chemicals to disperse or coalesce spills on water. (This last technique requires special approval of Federal and State agencies.)

6. Removal - Removal of spilled material, absorbents and the associated debris will be initiated immediately following the implementation of the containment procedures outlined above. Immediate removal is important since the cleanup may take several days, and changing weather conditions and/or equipment malfunctions may expand a controlled spill unless removal of spill

is made as early as practicable. Specific removal methods will be developed. The preferred method of disposal of the removed oil or other hazardous material is delivery of it to a processing facility. Other available methods include: burning in place; absorbing and burning; absorbing and burial in an approved landfill.

7. Cleanup and Restoration - After removal of the spilled material, cleanup of the contaminated area may involve the removal of soaked soil, debris and contaminated vegetation. Additional cleanup can be effected by scrubbing soiled structures with detergent solutions. The extent of cleanup should balance potential ecological damage from the cleanup operations against the potential ecological damage of allowing some of the spill residue to remain for natural biodegradation. Contaminated soils will normally be disposed of in an approved landfill.

B. Transportation-Related Facilities - This section describes the oil spill contingency plan for spills related to the product pipeline. Procedures for coping with all phases of the accident including notification procedures, containment of the spill, cleanup and repairs are described.

The primary objective is to prevent, as far as practical, any damage from an oil spill to persons, property, flora and fauna.

1. Responsibility and Notification - All oil leaks, whether reported by employees, aerial patrol, land owners along the right-of-way, and others, or from the pipeline's operational data shall be investigated immediately by the process superintendent.

Oil spills having no pollution potential shall be rectified immediately (repaired and cleanup made) by the process superintendent with the help of the maintenance superintendent, if needed. Oil spills having a pollution potential shall be reported immediately to the operations manager.

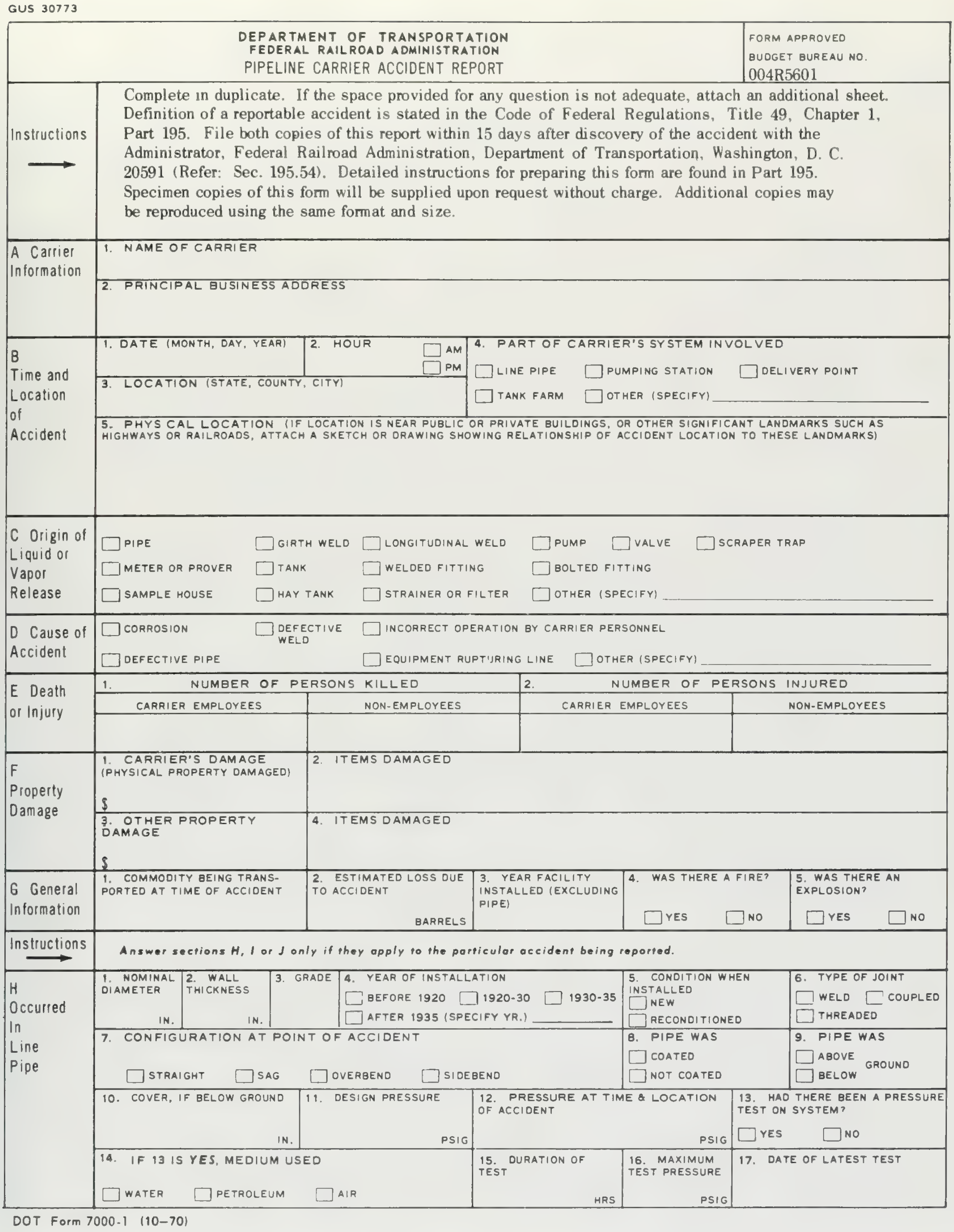
Based on oil spill data received, the general manager will decide which agency or agencies should be notified and through proper reporting channels will notify the appropriate agencies.

A Pipeline Carrier Accident Report, Figure 9-7-2, must be sent to the Department of Transportation in the event of any of the following:

- Explosion or fire not intentionally set by the carrier.
- Loss of 50 or more barrels of liquid.
- Escape to the atmosphere of more than five barrels a day of liquefied petroleum gas or other liquefied gas.
- Death of any person.
- Bodily harm to any person resulting in one or more of the following:
    - Loss of consciousness.
    - Necessity to carry the person from the scene.
    - Necessity for medical treatment.
    - Disability which prevents the discharge of normal duties or the pursuit of normal activities beyond the day of the accident.
- Property damage of at least $1,000 to other than the carrier's facilities, based upon actual cost or reliable estimates.

A notice by telephone is required at the earliest practicable moment following discovery of a spill in the event the spill:

- Caused a death or a personal injury requiring hospitalization;
- Resulted in either a fire or explosion not intentionally set by the carrier;
- Caused estimated damage to the property of the carrier or others, or both, of a total of $5,000 or more;
- Resulted in pollution of any stream, river, lake, reservoir, or other similar body of water that violated applicable water quality standards, caused a discoloration of the surface of the water or adjoining shoreline, or deposited a sludge or emulsion beneath the surface of the water or upon adjoining shorelines; or



GUS 30773

DEPARTMENT OF TRANSPORTATION FEDERAL RAILROAD ADMINISTRATION PIPELINE CARRIER ACCIDENT REPORT	FORM APPROVED BUDGET BUREAU NO. 004R5601

Instructions → Complete in duplicate. If the space provided for any question is not adequate, attach an additional sheet. Definition of a reportable accident is stated in the Code of Federal Regulations, Title 49, Chapter 1, Part 195. File both copies of this report within 15 days after discovery of the accident with the Administrator, Federal Railroad Administration, Department of Transportation, Washington, D. C. 20591 (Refer: Sec. 195.54). Detailed instructions for preparing this form are found in Part 195. Specimen copies of this form will be supplied upon request without charge. Additional copies may be reproduced using the same format and size.

A Carrier Information

1. NAME OF CARRIER
2. PRINCIPAL BUSINESS ADDRESS

B Time and Location of Accident

1. DATE (MONTH, DAY, YEAR)
2. HOUR ☐ AM ☐ PM
3. LOCATION (STATE, COUNTY, CITY)
4. PART OF CARRIER'S SYSTEM INVOLVED
☐ LINE PIPE ☐ PUMPING STATION ☐ DELIVERY POINT
☐ TANK FARM ☐ OTHER (SPECIFY) ____________
5. PHYSICAL LOCATION (IF LOCATION IS NEAR PUBLIC OR PRIVATE BUILDINGS, OR OTHER SIGNIFICANT LANDMARKS SUCH AS HIGHWAYS OR RAILROADS, ATTACH A SKETCH OR DRAWING SHOWING RELATIONSHIP OF ACCIDENT LOCATION TO THESE LANDMARKS)

C Origin of Liquid or Vapor Release

☐ PIPE ☐ GIRTH WELD ☐ LONGITUDINAL WELD ☐ PUMP ☐ VALVE ☐ SCRAPER TRAP
☐ METER OR PROVER ☐ TANK ☐ WELDED FITTING ☐ BOLTED FITTING
☐ SAMPLE HOUSE ☐ HAY TANK ☐ STRAINER OR FILTER ☐ OTHER (SPECIFY) ____________

D Cause of Accident

☐ CORROSION ☐ DEFECTIVE WELD ☐ INCORRECT OPERATION BY CARRIER PERSONNEL
☐ DEFECTIVE PIPE ☐ EQUIPMENT RUPTURING LINE ☐ OTHER (SPECIFY) ____________

E Death or Injury

1. NUMBER OF PERSONS KILLED		2. NUMBER OF PERSONS INJURED	
CARRIER EMPLOYEES	NON-EMPLOYEES	CARRIER EMPLOYEES	NON-EMPLOYEES

F Property Damage

1. CARRIER'S DAMAGE (PHYSICAL PROPERTY DAMAGED) $	2. ITEMS DAMAGED
3. OTHER PROPERTY DAMAGE $	4. ITEMS DAMAGED

G General Information

1. COMMODITY BEING TRANSPORTED AT TIME OF ACCIDENT	2. ESTIMATED LOSS DUE TO ACCIDENT BARRELS	3. YEAR FACILITY INSTALLED (EXCLUDING PIPE)	4. WAS THERE A FIRE? ☐ YES ☐ NO	5. WAS THERE AN EXPLOSION? ☐ YES ☐ NO

Instructions → ***Answer sections H, I or J only if they apply to the particular accident being reported.***

H Occurred In Line Pipe

1. NOMINAL DIAMETER IN.	2. WALL THICKNESS IN.	3. GRADE	4. YEAR OF INSTALLATION ☐ BEFORE 1920 ☐ 1920-30 ☐ 1930-35 ☐ AFTER 1935 (SPECIFY YR.) ________	5. CONDITION WHEN INSTALLED ☐ NEW ☐ RECONDITIONED	6. TYPE OF JOINT ☐ WELD ☐ COUPLED ☐ THREADED

7. CONFIGURATION AT POINT OF ACCIDENT ☐ STRAIGHT ☐ SAG ☐ OVERBEND ☐ SIDEBEND	8. PIPE WAS ☐ COATED ☐ NOT COATED	9. PIPE WAS ☐ ABOVE GROUND ☐ BELOW GROUND

10. COVER, IF BELOW GROUND IN.	11. DESIGN PRESSURE PSIG	12. PRESSURE AT TIME & LOCATION OF ACCIDENT PSIG	13. HAD THERE BEEN A PRESSURE TEST ON SYSTEM? ☐ YES ☐ NO

14. IF 13 IS ***YES***, MEDIUM USED ☐ WATER ☐ PETROLEUM ☐ AIR	15. DURATION OF TEST HRS	16. MAXIMUM TEST PRESSURE PSIG	17. DATE OF LATEST TEST

DOT Form 7000-1 (10-70)

Figure 9-7-2

PIPELINE CARRIER ACCIDENT REPORT

I Caused by Corrosion	1. TYPE OF CORROSION ☐ INTERNAL ☐ EXTERNAL	2. FACILITY COATED ☐ YES ☐ NO	3. FACILITY UNDER CATHODIC PROTECTION? ☐ YES ☐ NO	4. TIME BETWEEN CORROSION TESTS MONTHS	5. TYPE OF TEST USED
J Caused by Equipment Rupturing Pipeline	1. DISTANCE TO CLOSEST LINE MARKER	2. INFORMATION ON MARKER			3. LENGTH OF TIME BETWEEN PATROL ON SECTION DAYS

ACCOUNT OF ACCIDENT BY RESPONSIBLE OFFICIAL OF CARRIER

NAME AND TITLE OF CARRIER OFFICIAL FILING THIS REPORT	TELEPHONE NO. (INCLUDE AREA CODE)	DATE

Figure 9-7-2 (continued)
PIPELINE CARRIER ACCIDENT REPORT

- In the judgment of the carrier, was significant even though it did not meet the criteria of any other subparagraph of this paragraph.

In addition to the Department of Transportation, when a spill of any kind occurs which does or may reach any waters of the state, surface or underground, the spill will be reported at once to the following:

- Colorado Water Pollution Control Division, Denver, Colorado, Phone: (303) 388-6111, Ext. 231
- Area Oil Shale Supervisor, U. S. Geological Survey, Grand Junction, Colorado
- Environmental Protection Agency, Denver, Colorado, Phone: (303) 837-3880
- Bureau of Land Management, Craig, Colorado

Spills which occur in sloughs, ponds, or other surface waters where there is any possibility of harm to fish or aquatic life and spills occurring on land where there is any possibility of harm to game or wildlife habitat will be reported as well to the State Division of Wildlife.

If it appears that domestic water users downstream may be affected, then immediate notification to these users will be made. Notification will be accomplished by contacting the local mayor, water superintendent, city engineer, city police, town marshall, sheriff's office, etc. In the event that the spill is near or over a road or highway and it is necessary to reroute traffic, the Colorado State Patrol will be alerted at once.

2. Locate and Identify Source of Discharge - The precise physical location of the source of the oil spill must be determined immediately. Company personnel receiving a report of a leak will obtain all available pertinent information. A standard leak report form will be used for receiving and recording information.

Reports of leaks are often received from outside parties who are unfamiliar with the operations of the company or with terminology used in the business. Often such reporters are vague as to location. Such persons will be questioned fully to: locate the leak in respect to a known landmark; obtain accurate and adequate information as to the nature of the leak; and obtain information as to conditions at the leak site. The source of discharge will be plotted accurately with reference to known areas on the pipeline route map.

This information is valuable not only in accurately locating the leak, but, also, to assist repair crews in selecting repair and containment equipment to be dispatched to the site.

The process superintendent will be notified immediately and furnished with all available information so that he can stop the leak and arrange for maintenance crews and equipment to be dispatched to the site as quickly as possible. If the physical location or extent of the leak cannot be determined readily, experienced personnel will be sent to the scene, and if necessary, arrange for aerial patrol flights over the suspect area.

3. Stop Discharge - Prompt action in stopping the discharge or reducing the flow to an oil spill can be the difference between an incident of minor importance and a major accident. In the case of an oil spill or leak, the line will be shut down immediately if not already automatically shut down.

As soon as the location of the leak is determined, appropriate action will be taken to stop the discharge of oil at the point of the leak. This may require temporary repairs and isolation of sections of the line to prevent drainage of the pipeline or pumping down the section containing the leak.

4. Contain Spill - Containment of the spilled oil will be a concurrent activity with the stoppage of discharge. Oil may be contained in bell holes, or through the construction of catchment basins, earthen dams, separators, weirs, or other appropriate means.

Natural avenues of escape such as streams, waterways, ditches, and gullies will be followed on foot to determine that oil has not passed on or through them. If oil is found, containment facilities will be constructed. In some cases, such facilities must be constructed well ahead of the actual oil movement, if it is apparent that the oil will reach that point before containment facilities are constructed.

Contained oil will be picked up as quickly as possible to prevent further movement of the oil and to reduce hazards. Any appropriate means such as suction tank trucks, pumps, skimmers and floating booms will be used for cleanup from water surfaces.

5. Evaluate and Cope with Hazards - In order to minimize possible bodily injury, loss of life, property damage, loss of wildlife, or air or water pollution, time is of the essence in making an accurate analysis of hazards and potential hazards. All existing or potential hazards must be identified according to basic nature. There may be other hazards besides the obvious ones of fire, explosion, and pollution.

Oil discharges in congested areas, waterways, and watersheds draining into streams or impoundments from which private or public potable water supplies are drawn will require special precautionary measures.

When an oil spill poses an immediate or potential threat or hazard to the properties of third parties, these parties will be notified and consulted in any decisions which might affect their operations or facilities.

6. Repair and Cleanup - Repair will be started as soon as possible after the work area is judged to be safe and after all necessary precautionary measures have been satisfied. Repair and oil recovery should proceed simultaneously and must be closely coordinated. Cleanup operations should be prompt and thorough in all respects and will be completed as stated previously.

7. Evaluate and Complete Reports - A thorough analysis and report will be made of circumstances and handling of each oil spill. The experience gained from each such occurrence provides the best guideline for updating the contingency plan to handle future oil spills. Follow-up actions are extremely important and will include such items as training of personnel, assessment of equipment and evaluation of policies and procedures.

CHAPTER 8

LAND REHABILITATION

CHAPTER 8
LAND REHABILITATION AND EROSION CONTROL

This chapter discusses rehabilitation in terms of the environmental concern for the return of disturbed lands to a condition compatible with the stated purposes of the Tract C-a lease. The objectives of the land rehabilitation program described in this chapter are to reclaim disturbed areas by returning them to a state that does not contribute to environmental deterioration and is consistent with surrounding aesthetic values.

The overall concept of rehabilitation efforts for the project includes numerous problems and considerations dealing with mining, access, plant sites, parking lots, conveyor corridors, access roads, transmission lines, pipelines, etc. The principal elements considered in this chapter are site preparation, erosion control and revegetation.

8.1 AREAS AFFECTED

Table 9-8-1 shows estimates of the yearly disturbed surface areas and areas ready for rehabilitation for the Phase I and Phase II operations. The Rangely access road, power line and telephone line are excluded because they will be constructed and rehabilitated by other entities i.e. Rio Blanco County, Moon Lake Electric and Mountain Bell.

8.2 SITE PREPARATION

Site preparation, or the shaping and grading of areas being rehabilitated, is controlled by three primary environmental concerns: erosion control, aesthetics and type of flora to be supported. One additional factor influencing the rehabilitation work is the chosen method of constructing an artificial soil profile on the processed shale and overburden disposal piles to facilitate

Table 9-8-1

ESTIMATED ACREAGES DISTURBED AND REHABILITATED DURING PHASE I AND II*

	Disturbed										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986-2015	Total
Open Pit Mine and Facilities	25	50	30	5	15	15				630	770
Processing Facility	100			15		135					250
Processed Shale and Overburden Disposal Area		110	60	25	30	55	35	60	25	3,650	4,050
Support Facilities											
Internal Roads, Conveyors and Power Distribution Lines	65	110							50		225
Product Pipeline		60									60
Water Control Facilities		100	25	15						260	400
Total	190	430	115	60	45	205	35	60	75	4,540	5,755

	Rehabilitated									
	1978	1979	1980	1981	1982	1983	1984	1985	1986-2015	Total
Processed Shale and Overburden Disposal Area	45	50	25	30	35	35	35	50	3,745	4,050
Support Facilities										
Internal Roads, Conveyors and Power Distribution Lines	30		50						25	105
Product Pipeline	60									60
Water Control Facilities	55	25	15							95
Total	190	75	90	30	35	35	35	50	3,770	4,310

*Includes 30 years at Phase II production rate but assumes operation continues after 2015 so many of the affected areas are not shown as rehabilitated.

revegetation. Chapter 10 of this section covers aesthetics, and erosion control is discussed in part 8.3 of this chapter.

A. Soil Conservation - Soil is considered an important natural resource in the Piceance Creek Basin. Topsoil and subsoil will be stripped from all disturbed areas and stockpiled for later use in revegetation. Topsoil, which comprises the upper layer of soil (0 to 8 inches) contains organic matter, nutrients and biological activity. Subsoil comprises the stratum beneath the surface topsoil and ranges to bedrock. Subsoils which have limited nutrients and organic matter available for plant growth will generally be covered with topsoil to ensure re-establishment of vegetation.

Topsoil excavated for roadway construction operations will be stockpiled in selected areas along the alignment for reuse to cover cut-and-fill slopes. Soils excavated from the mine area will be stockpiled for later reuse to cover processed shale or overburden and to rehabilitate the mine. The topsoil and subsoil in the disposal area will also be excavated and stockpiled separately in an area where it can be reused later.

In the processed shale and overburden disposal areas the initial stripping will be on only about 40 acres. This material will be stockpiled and used as required. At that time nutrients will probably be added in order to restore fertility in the soil. Additional stripped material will be transported directly onto the overburden and processed shale piles as they reach final configuration, thereby eliminating the loss of biological and organic matter inherent in any long term stockpiling process.

Larger pieces of overburden rock may be piled at locations on the disposal pile to enhance the aesthetics by breaking up uniform lines and surfaces and also to control erosion.

B. Artificial Soil Profile - Overburden will need only the addition of soil. Special treatments will be applied to the surface of the processed shale disposal pile because the soluble salts in the processed shale, if uninhibited, may migrate by capillary action to the surface during the summer months. It is anticipated that the salt would be deposited near the ground surface and form an alkaline environment unfavorable for plant growth. Continuous maintenance activity in the form of leaching and irrigation would be required to revegetate processed shale with only the addition of the small amount of soil available.

To avoid the necessity for extensive leaching of salts from the surface of the processed shale, an artificial soil profile will be developed. This artificial soil profile will consist of a layer of rock to stop capillary movements of moisture from the processed shale upward toward the root zone. The rock will be covered with subsoil and topsoil. Upward mositure migration in the liquid phase is not anticipated across the rock layer. However, the rock layer will not interfere with the movement of small amounts of moisture in the vapor phase, and additionally will prevent soluble salts from migrating toward the surface. Figure 9-8-1 illustrates a cross section of the processed shale disposal pile with the artificial soil profile in place. For more information on the individual layers of the artificial soil profile see Part 8.4 of this section.

The thickness of the soil will be determined prior to construction in order that sufficient material will be available to cover the entire surface of processed shale and overburden. The quantities of soil are being determined by a soil survey currently in progress. Topsoil will be placed on top of the subsoil. The quantities are yet to be determined, but it is anticipated that 6 to 10 inches of topsoil will be available.

One major problem in developing an artificial soil profile on top of the processed shale is retention of sufficient soil moisture to provide for the year's growth of vegetation. It is expected that the soil profile underlain by the rock layer will have a higher field moisture capacity than one placed directly on the processed shale. Normally, in natural soil profiles, a topsoil underlain by a sand layer has a higher field capacity than the same soil without the underlying sand layer. Properties of the processed shale may alter water retention characteristics enough to cause some deviations.

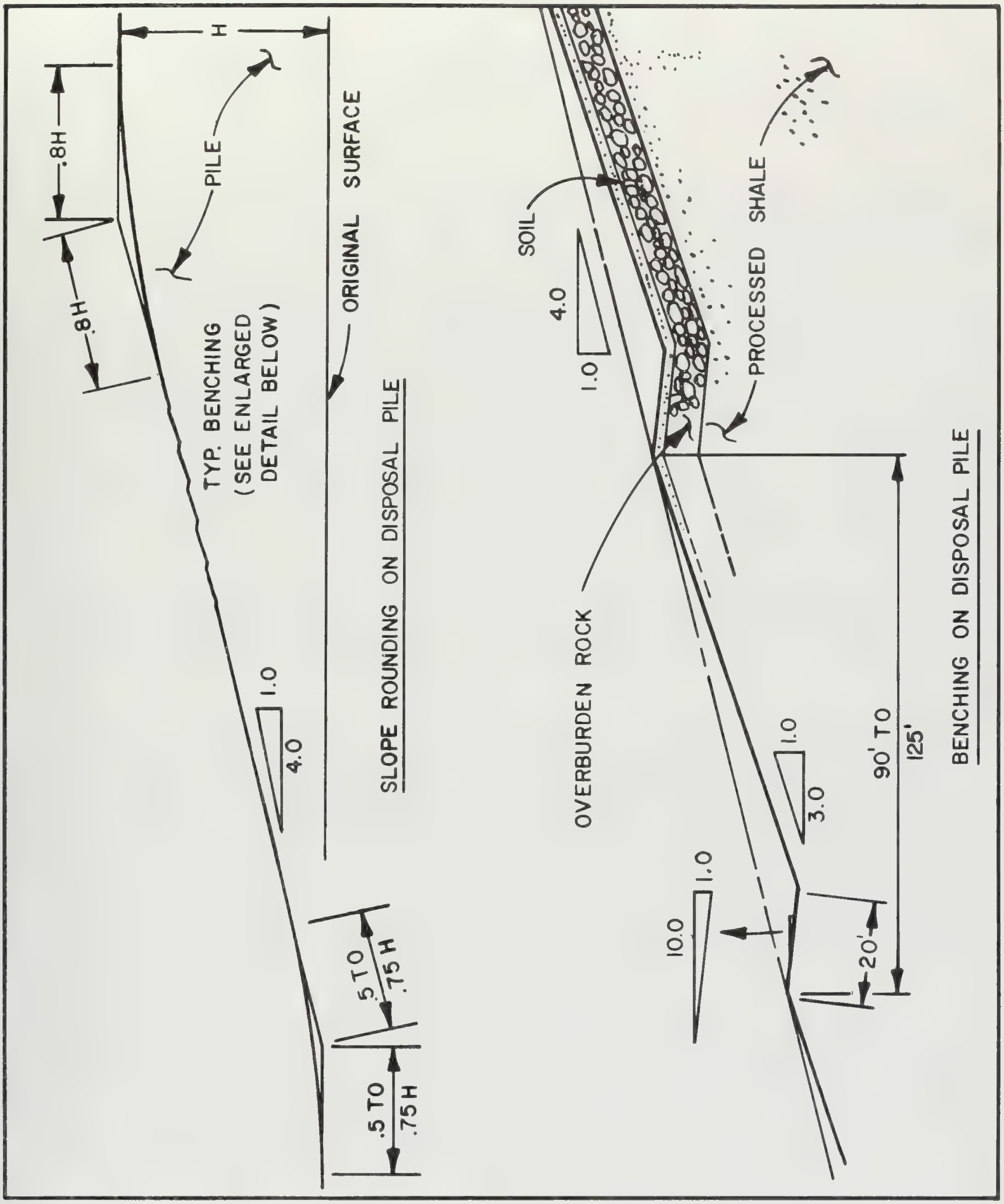


Figure 9-8-1

DISPOSAL PILE CROSS SECTION

The artificial soil profile described above will be constructed initially, but as more is learned about the revegetation of processed shale, it may become desirable at some future time to change the artificial soil profile to obtain the desired results more effectively.

8.3 EROSION CONTROL

Erosion is a process by which the land surface is worn away by the action of water, wind, ice or gravity. Although erosion occurs naturally, as part of the weathering cycle, it is accelerated by mining and construction activities. Physical disturbance exposes materials to erosion mechanisms and increases the rate of erosion. Moving water is responsible for most erosion; however, wind erosion is also a significant factor. Gravity and ice will not be of major importance to the project.

The following paragraphs deal mainly with erosion by water; however, treatments to prevent water erosion and sedimentation are also equally applicable to wind erosion.

A. Material Size and Classification - Gravelly soils and/or boulders are not likely to erode. Undisturbed clay particles, although very small, are usually erosion resistant because of bonds produced by electrical imbalances within the unit cells of the soil particles. Most soils on the tract and the waste materials fall somewhere between these two limits. Processed shale would nominally be classified as silt, an easily erodible material.

Soil erodibility can be rated according to grain size (percent of silt and very fine sand), structure, permeability and organic matter. A given material will be more resistant if it can be made more permeable (more infiltration and less runoff). The least desirable combination of materials from an erosion resistance point of view is a high range (30 to 70%) of silt and very fine sand. One of the most basic and obvious erosion control measures applicable to all slopes is the use of a coarse material as a cover layer. The longer and steeper the slope, the thicker should be the layer of material.

B. Slope and Surface Treatment - Slope roughening practices, such as scarification and serrated slopes, will be used to decrease runoff, as well as to slow the water movement. These practices reduce the ability of moving water to detach soil particles and transport sediments. Some of the proposed practices include:

- Slope roughening by scarification along the contour of a graded slope. The grooves spread the runoff horizontally, slow its movement downslope and increase the infiltration rate. Roughening is also beneficial in the establishment of vegetation on a graded area. The horizontal grooves retain soil additives, seeds and mulch that might otherwise be washed down the slope. This practice also increases moisture retention and loosens the soil in the plants' root zone.
- Operating a bulldozer up and down a graded slope. This practice is referred to as "tracking" and is more adaptable to steep slopes than scarification. "Tracking" does not loosen the soil as much as scarification, and the resulting compacted soil may be more beneficial on long or steep slopes exposed to high intensity rainfall.
- Pockets developed on slopes at varying intervals.

All other factors being equal, a long slope will collect more runoff than a short slope. The greater concentration of water at the base of the longer slope increases the likelihood of erosion. To minimize this problem, long slopes will be constructed to function as a series of short slopes by utilizing diversion features, such as benches, terraces, ditches or dikes. Benching, shown on Figure 9-8-1, is planned for waste disposal. The benches will be carried laterally to a point where drainage can be emptied into a riprapped channel, which will carry the water off the slope.

Selective spreading of individual large rocks may be included in this treatment to provide energy dissipation and shade for new plants, and to break up regular structural lines and improve the appearance.

C. Drainage - Facilities will be provided to drain interception ditches and benches, and to direct the flow of water into erosion resistant areas or into specially designed channels. The basic drainage elements will be interception ditches, dikes and channels.

As required, a number of special disposal structures will be used including drain pipes, down drains, chutes and flumes. These disposal structures will be designed to handle the water and sediments that occur as a result of an unusually heavy downpour on bare soil areas. They will be designed for both permanent and temporary use.

Water bars and breaks will be constructed to divert water from unsurfaced roadways into natural drainage. To keep flows in road ditch sections from reaching dangerous proportions, cross drains will be installed in addition to regular drains. The following table as per BLM specifications provides a general guide for spacing both water bars and cross drains. Flow velocities will be controlled by energy dissipation devices, such as check dams, plunge pools and rock wiers.

WATER BAR AND CROSS DRAIN SPACING

Road Gradient (%)	Distance Between Water Bars and Cross Drains (ft)
Less than 2	200
2 to 4	100
4 to 5	75
5	50

D. Temporary Measures - Temporary erosion control measures will be provided as required at all sites where grading has been done and revegetation has not been completed. Shielding and/or protecting the soil can be accomplished in different ways. A wide variety of products is available commercially, and some materials can be found locally.

1. Cover Material - Choosing the best cover material is a matter of convenience, cost, ultimate purpose and effectiveness. When the cover material is

applied as an initial step in revegetation, it should also have good mulching characteristics. Some of the materials that are being considered for this project, their application rates and special conditions are listed below:

- Straw (2 tons per acre) - Straw is versatile, effective, easily obtained, but is susceptible to wind damage.
- Emulsions (500 to 800 gallons per acre) - Emulsions provide a quick, effective cover and are normally effective in wind. It is often combined with straw to provide good ground cover.
- Chemical binders - Various sprays of dust stabilizing agents or glue-like substances can be used. These binders generally penetrate into the surface of the soil before they set, combining with individual soil grains to form a mat.
- Cellulose fibres (1 ton per acre) - Cellulose fibres can be applied using hydroseeding techniques.
- Jute netting and mats - Jute netting and mats are temporary but quick and easy to apply as a good, instant ground cover.
- Plastic matting and nets - Normally they give an excellent lasting cover and the vegetation will normally grow through the material openings.

Obviously there are many products not included above that will prove to have special value. A great number of chemicals and emulsions that have been tested on highway cuts and fills as well as waste piles include: silicates, lignosulphates, pyrite treated with sulphuric acid, cement, lime, cationic neoprean emulsions, elastromeric polymers, resinous material, bituminous base products, cellulose compounds, various oil fractions, amines, waxes, tar and pitch emulsions. Special problems will require a careful evaluation of materials and sometimes field testing of several to obtain satisfactory results.

2. Cover Criteria - While slopes are under construction, enough temporary cover material, of the kind quickly applicable in any weather, will be kept on hand to cover erodible exposed slopes whenever necessary. Surface roughness of the slopes will also help prevent erosion.

Seeding and plant operations are restricted seasonally, and slopes constructed between seasons will be quite vulnerable to erosion. Temporary cover of some slopes is needed depending upon exposure, material, surface areas, steepness, etc. The following table indicates generally the criteria for application of temporary cover material or mulch on various sloped surfaces.

Slope areas, consisting of over 50% of loose rock, talus or other blocky material, will not normally require temporary covers.

Slope	Cover Criteria
10%	If the run[1/] exceeds 8 feet
6 - 10%	If the run exceeds 12 feet
3 - 6%	If the run exceeds 25 feet
0 - 3%	If slopes have been scarified or perforated adequately to retain all moisture in surface depressions, generally no cover is required except for specific, unstable, or highly hazardous conditions.

[1/] "Run" is defined as the maximum length that water will travel without provision of some form of retention.

The nearly horizontal portion of benches with reverse back slopes will not be covered; however, the sloping portions of the benches will require protective measures.

The working faces of disposal piles will not normally receive any temporary cover, except that a temporary cover will be applied if necessary to prevent significant erosion whenever a slope has been completed, and revegetation cannot commence before the start of wet weather.

8.4 REVEGETATION

The RBOSP mining operations will disturb land on and off Tract C-a and a reclamation program will be required. The areas disturbed by the RBOSP mining operation will be primarily associated with the construction of plant site, access roads, pipeline, water control structures and disposal of processed shale. Alternative methods of reclamation include revegetation, crop production, covering disturbed areas with rock, or abandonment. Where feasible, revegetation provides the most self-sustaining and aesthetically pleasing means of rehabilitation. In accordance with the spirit of the lease stipulations, RBOSP's intent is to reclaim disturbed areas in such a way that the net result of the subsequent reclamation will be that flora and fauna of the area will be equivalent to or better than that which existed prior to disturbance.

Baseline studies are currently being conducted to determine the numbers and kinds of these fauna. These data are presented in Section 3, Chapter 7. The present fauna consists of mule deer, feral horses, domestic livestock, and small herbivores and predators. They can be supported if a plant community is reestablished which has a species composition and productivity similar to that presently existing. Baseline studies provide data on existing range trend, browse and soil conditions, and forage production. These conditions characterize the quality of vegetation which must be reestablished in accordance with the lease stipulations.

A. Revegetation Technology - Revegetation in the semi-arid West is limited by low soil moisture, the scarcity of suitable irrigation water and alkaline or saline soil conditions. In disturbed areas where soil substrates are revegetated directly, the use of proper reclamation planning and revegetation technology can largely eliminate or at least minimize some of these limitations. In contrast, the rehabilitation of the processed shale disposal areas requires greater effort. Processed shale exhibits physical, chemical and hydrological characteristics which may limit revegetation success (Striffler, et al., 1974) and the physical stabilization of the piles (See Section 7, Chapter 3). The high salt content of processed shale requires extensive leaching before the salinity is reduced to a level suitable for plant growth. Additional leaching may be necessary if salts migrate upward into the rooting zone. Also, leaching may not remove all toxic elements such as heavy metals. Harbert and Berg (1974) have shown that the heavy metals, zinc and molybdenum, may concentrate in vegetation at levels which are known to be toxic to cattle when ingested.

Substrate temperatures high enough to prevent normal seed germination may result from absorption of sunlight due to the dark color of the processed shale (Schmehl and McCaslin, 1973).

Extensive studies have been done to determine successful means of revegetating processed shale (Berg, 1975; Block and Kilburn 1973; Culbertson, et al., 1974; Harbert and Berg, 1974; Lipman, 1975). These studies indicate that revegetation on processed shale is successful if the shale is leached to a depth suitable for plant growth and if adequate water and nutrients are available. It is not presently known if a long-term, self-sustaining plant community can be maintained without continuous management. An alternative to revegetating the processed shale directly is to cover the spoils with a non-toxic substrate, such as overburden or soil, in order to provide a medium more suitable for plant growth. This alternative is planned for reclamation of the processed shale disposal pile on Tract C-a.

The following discussion outlines the available revegetation technology most appropriate for reclaiming the disturbed lands resulting from RBOSP mining operations. Reclamation of disposal piles on Tract C-a will not be accomplished by revegetating processed shale directly, rather, an artificial soil profile will be constructed to eliminate the effects of the adverse physical and chemical properties of processed shale. Therefore, the approach described is generally applicable to the reclamation of both the disposal piles and areas disturbed by construction activities.

1. Seedbed Preparation - All areas should be cleared of debris and large rocks which might hamper operation of machinery, and contoured to a slope not steeper than 3:1. Slopes steeper than 3:1 limit the use of machinery for seeding operations and increase soil erosion potential. When possible, topsoil will be stockpiled and then replaced after contouring. In areas where topsoil is not available, the substrate surface will be scarified and left in furrows to reduce erosion potential until suitable vegetation has been established.

The site preparation of the disposal pile will be more extensive than surface disturbed areas. Preliminary designs recommend a typical disposal pile to have the following strata, from top to bottom:

0.1 - 0.2 m (1/3 - 1/2 ft) of topsoil
0.3 - 0.3 m (1/2 - 1 ft) of subsoil
0.3 - 0.6 m (1 - 2 ft) of crushed rock)
)-"overburden"
0.6 - 0.9 m (2 - 3 ft) of large boulders)
1.5 m (5 ft) of 95% compacted processed oil shale
0 to several hundred meters of 80% compacted processed oil shale
1.5 m (5 ft) of 95% compacted processed oil shale

(The above values represent a minimum range in depths for each strata.) Further details of the disposal pile preparation are included under 8.2 SITE PREPARATION.

This artificial soil profile should provide an adequate quantity and quality of rooting medium to support plant cover and minimize direct root contact with the processed shale. The large soil pore size associated with the overburden should prevent capillary movement of salts from the processed shale into the rooting zone. Thus, the artificial soil profile is expected to eliminate the adverse effects of processed shale on the reestablished vegetation.

2. Seeding - Seeding should be done prior to the period of greatest precipitation. In western Colorado, seeding has been successful when done in late fall or early spring, but late fall (September 15 to November 15) is generally preferable (Cook, et al., 1974). If an area is seeded too early in the fall, seeds may germinate and subsequently be killed by the low winter temperatures. Late fall seedings may also be hampered by inclement weather. Seeding on Tract C-a will probably be carried out during the optimal fall period unless disturbed areas, available for revegetation in spring, would benefit from immediate rehabilitation.

Since the RBOSP mining operation is expected to disturb land in a number of vegetation types, the plant species to be seeded will be broadly adaptable and may include several species mixtures. Numerous studies have been conducted to investigate the performance and adaptability of various plant species in vegetation types typical of those occurring on Tract C-a (Cook, et al., 1974; Cook, et al., 1970; Doran, 1952; Harbart and Berg, 1974; Hull and Doran, 1950; Merkel, et al., 1972; Merkel and Currier, 1973; Plummer, 1970, Simms and Redente, 1974; USDA - Soil Conservation Service, 1974). Certain plant species have demonstrated success in the vegetation types occurring naturally in the vicinity of Tract C-a and will be further tested for use in these areas (Table 9-8-2). The list includes species adapted to exacting environmental conditions normally occupied by a single vegetation type while others are adapted to a wide array of environmental conditions and native vegetation types.

Seeds will be sown in a composite mixture of grasses and forbs, or as a pure mixture of grasses or forbs. In the vicinity of Tract C-a, Sims and Redente (1974) have investigated the adaptability of various plant species sown in pure stands.

Studies have not investigated the seeding of composite mixtures of grass, forb and shrub species. Seeding of composite mixtures including shrubs should accelerate succession due to the potential early introduction of woody plant species. The choice of pure or composite mixtures depends on the conditions and size of the disturbed areas. For example, small areas along roads can be seeded with a grass-forb mixture for initial establishment, while shrubs are usually established by invasion from adjacent areas. In larger areas, a mixture of grass, forb and shrub species will be included in the seed mixture providing for more rapid introduction of browse and cover for wildlife species.

Native plant species will be given preference to reduce the possibility of introducing undesirable species. Because of the success already demonstrated with a number of introduced species in the area (Sims and Redente, 1974), the use of additional exotic species may not be necessary for this reclamation program.

The foothill zone of the Piceance Creek Basin has a moderate potential for rehabilitation. This potential increases at higher elevational zones where precipitation increases (Terwilliger, et al., 1974). It is expected that all areas disturbed by the RBOSP operation will be successfully revegetated if suitable technology is used.

Table 9-8-2. Plant species recommended for seeding in vegetation types occuring within the vicinity of RBOSP Oil Shale Tract C-a.

	Vegetation Type				
Plant Species	Saltbush Scrub	Sagebrush Scrub	Pinyon-Juniper	Mountain Brush	Aspen
Russian wildrye	X^{a}	X^{a}	X^{a}	X^{a}	X^{a}
Indian ricegrass	$X^{a,c}$	$X^{a,c}$	$X^{a,c}$		
Alkali sacaton	$X^{a,c}$	X^{c}			
Bottlebrush squirreltail	X^{a}				
Crested wheatgrass	X^{c}	$X^{a,b,c}$	$X^{a,b,c}$	$X^{a,b,c}$	X^{a}
Western wheatgrass		X^{a}	$X^{a,b}$	$X^{a,b}$	X^{a}
Bluebunch wheatgrass		$X^{a,c}$	$X^{a,c}$		
Pubescent wheatgrass		$X^{a,b,c}$	$X^{a,b,c}$	$X^{a,b,c}$	X^{a}
Intermediate wheatgrass		$X^{a,b,c}$	$X^{a,b,c}$	$X^{a,b}$	X^{a}
Streambank wheatgrass		$X^{a,b}$	$X^{a,b}$	$X^{a,b}$	
Tall wheatgrass		X^{a}	$X^{a,b}$	$X^{a,b}$	
Thickspike wheatgrass		X^{b}	X^{b}	$X^{a,b}$	
Slender wheatgrass			X^{a}	X^{a}	X^{a}
Beardless wheatgrass				X^{a}	X^{a}
Bearded wheatgrass					X^{a}
Sand dropseed		X^{a}	X^{a}		
Mountain brome		X^{b}	$X^{a,b,c}$	$X^{b,c}$	
Reager meadow brome		X^{b}	$X^{b,c}$	$X^{b,c}$	
Smooth brome				$X^{a,c}$	X^{a}
Green needlegrass		X^{b}	$X^{a,b}$	X^{b}	
Basin wildrye		$X^{a,c}$		$X^{b,c}$	X^{a}
Hard fescue		X^{c}		$X^{a,c}$	X^{a}
Sheep fescue				X^{a}	
Arizona fescue				X^{a}	
Idaho fescue				X^{a}	
Orchard grass				$X^{a,c}$	X^{a}
Big bluegrass				X^{a}	X^{a}
Tall oatgrass				$X^{a,c}$	X^{a}
Meadow fescue					X^{a}
Tall fescue					X^{a}

Table 9-8-2. (Continued)

Plant Species	Vegetation Type Saltbush Scrub	Sagebrush Scrub	Pinyon-Juniper	Mountain Brush	Aspen
Blue wildrye					X^{a}
Canada wildrye					X^{a}
Timothy					X^{a}
Alfalfa	X^{c}	$X^{a,b,c}$	$X^{a,b,c}$	$X^{a,b,c}$	
American vetch		X^{a}	X^{a}	X^{a}	X^{a}
Cicer milkvetch		X^{a}	X^{a}	X^{a}	X^{a}
Yellow sweetclover		$X^{a,b,c}$	$X^{a,b,c}$	$X^{a,b,c}$	
Utah sweetvetch		$X^{b,c}$	$X^{a,b,c}$	$X^{a,b,c}$	
Rocky Mountain penstemon		X^{b}		X^{b}	
Bouncing bet		X^{b}	$X^{b,c}$	$X^{b,c}$	
Lewis flax		$X^{b,c}$	$X^{b,c}$	$X^{b,c}$	
Arrowleaf balsamroot		X^{c}	$X^{a,b,c}$	$X^{b,c}$	X^{a}
Palmer penstemon	X	X^{c}	$X^{b,c}$	a	
Gooseberry globemallow		X^{a}	$X^{a,b}$		
Small burnet			X^{b}		
Verbena			X^{b}		
Sweetanise			X^{b}		
Penngift crownvetch			$X^{b,c}$	$X^{b,c}$	
Sicklepod milkvetch					X^{a}
Winterfat	$X^{a,c}$	X^{b}	$X^{b,c}$		
Four-wing saltbush	X^{a}				
Shadscale	X^{a}				
Nuttall saltbush	X^{a}				
Greasewood	X^{a}				
Green ephedra	X^{a}	$X^{a,b,c}$	$X^{b,c}$	$X^{b,c}$	
Rubber rabbitbrush		X^{a}			X^{a}
Big sagebrush		$X^{a,c}$	$X^{a,c}$	$X^{a,c}$	X^{a}
Little rabbitbrush		$X^{a,b,c}$	$X^{a,b,c}$	X^{c}	
Bitterbrush		$X^{b,c}$	$X^{a,b,c}$	$X^{a,b,c}$	
Utah serviceberry		X^{c}	$X^{a,c}$	$X^{a,c}$	X^{a}

Table 9-8-2. (Continued)

Plant Species	Saltbush Scrub	Sagebrush Scrub	Vegetation Type Pinyon-Juniper	Mountain Brush	Aspen
Stansbury cliffrose		X^{b}	X^{b}	$X^{a,b}$	
Curl-leaf mahogany			$X^{a,c}$	X^{a}	
Mountain mahogany			$X^{a,c}$	$X^{b,c}$	
Common bladdersenna			$X^{b,c}$	$X^{b,c}$	
Black chokecherry			$X^{b,c}$	$X^{b,c}$	X^{a}
Snowberry					X^{a}
Aspen					X^{a}

Recommended by:

[a] Cook et al., 1974

[b] Sims & Redente, 1975

[c] Plummer, 1970

It has been shown that revegetation accelerates natural succession since the annual weedy stage is largely replaced by one of perennial grasses and forbs, enhancing the invasion of desirable native perennial forbs (Terwilliger, et al., 1974). By establishing a vegetative cover soon after disturbance, the invasion of undesirable species, e.g., halogeton (Halogeton glomeratus) and Russian thistle (Salsola kali), should be minimized. Thus, the preferred native vegetation may avoid competition with aggressive weedy species and can more easily be established in the area. Following establishment, natural secondary succession may continue for 20 - 50 years (Terwilliger, et al., 1974). The final species composition is impossible to predict and will depend on the available natural seed source in the area, climatic conditions during succession, and grazing by feral domestic animals, and wildlife.

Seeds of native plants are not now readily available but as more commercial firms become active in this area the availability of native plant seed is expected to improve. The planned SCS Plant Materials Center in Meeker may develop new improved varieties of seed, but the time necessary for such development is unknown at this time.

Common seeding methods include broadcasting or drilling. Drilling is limited to areas where the terrain allows operation of machinery. Drilling is preferred since it distributes the seed more uniformly and places it at a uniform depth (Cook, et al., 1970). It is generally accepted that broadcasting requires twice the amount of seed as required for drilling.

Broadcasting may be necessary on steep slopes or in small areas where operation of equipment is not feasible or not practical. After broadcasting, seed is covered by soil to provide a more favorable germination medium by means of a harrow or disk. Seed can be broadcast in a mulch mixture but this is not advisable for Tract C-a since the mulch will not remain moist long enough to permit suitable conditions for germination and establishment.

Rate of seeding will vary depending on site conditions and the growth form, e.g., grass or shrub, of the seeded species. Cook, et al., (1974) suggests that 7 - 15 lb of pure live seed (PLS) per acre is needed when seed is drilled in foothill areas. Grasses should be drilled at rates of 20 - 25 PLS per square foot in higher mountain brush and aspen vegetation zones. The USDA - Soil Conservation Service (1974) specified 40 PLS per square foot be seeded in non-irrigated critical area plantings. The rates of seeding for lands disturbed by RBOSP will range within these recommended rates. Any broadcasted seed will be sown at a rate double that recommended for drilling.

In certain critical areas, direct seeding may not result in the establishment of vegetation, particularly shrub species. In these areas the preferred shrub species can be outplanted in the form of seedlings. Containerized seedlings have recently received much attention (Tinus, et al., 1974) because of their potential for increasing moisture supply and rapid juvenile growth. In critical areas where natural establishment is minimal, it may be advantageous to use containerized seedlings.

3. Mulches - Mulch, often utilized in revegetation, hastens the establishment of vegetation by increasing water infiltration, moisture retention, and by moderating soil temperature and reducing evaporation. In addition, mulches minimize wind and water erosion until the vegetation becomes established.

Numerous mulches have been developed and tested to determine their suitability under different conditions. Advantages and disadvantages of some common mulches and their use in combination with artificial soil coverings or mattings are listed in Table 9-8-3. Less attention has been placed on the proper rate of mulch application (Mannering and Meyer, 1963; Meyer, et al., 1970) which is a critical factor for successful use of a mulch.

Straw, due to its demonstrated success, availability, and lower cost will probably be used most often. Straw will be crimped or used in combination with a soil covering, such as plastic or jute netting, to keep the mulch intact and in place. An application rate of 2 tons/acre will probably be used since it has been successful in other areas (Beard, 1966; Meyer, et al., 1970). The specific mulch to be used during reclamation will vary depending on the slope and size of the disturbed area. Table 9-8-3 indicates the appropriate mulch to be used under these conditions.

Table 9-8-3. Advantages and disadvantages of some common mulches and soil coverings available for use on disturbed areas in the vicinity of Tract C-a.

Mulch Type	Advantage	Disadvantage	Studies or Review
Straw (crimped)	High moisture retention, low erosion, readily available, relatively inexpensive	Contamination by weed seeds Susceptibility to fire	Springfield (1971) Beard (1966) Barnett et al. (1967) Dudeck et al. (1970)
Hay (crimped)	High moisture retention, low erosion, readily available, relatively inexpensive, usually less weed seeds than straw	Contamination by weed seeds Susceptibility to fire	Springfield (1971) Beard (1966) Barnett et al. (1967) Dudeck et al. (1970)
Straw plus asphalt	Effectively conserves moisture	Susceptible to wind and water erosion if improperly applied	Cook et al. (1970) McCully and Bowmer (1969)
Straw plus jute netting	Very effective for steep slope if applied correctly	May cause slope to slide and create gullies if applied incorrectly; some chemical substances in jute may inhibit germination of specific species	Jacoby (1969) Randall (pers. comm, 1975)
Straw plus plastic netting	Similar to straw, but increased erosion control	Netting is expensive; degrades slowly	Randall (pers. comm., 1975)

Table 9-8-3. (Continued)

Mulch Type	Advantage	Disadvantage	Studies or Review
Wood residues, sawdust, wood chips, bark	Adds organic matter, easy to apply, long-lasting.	Competition for available N, decreases pH if material fermented, packing of fine particles	Springfield (1971) Bollen (1969) Meyer et al. (1972)
Excelsior	Good soil protection	Expensive, laborious to apply, attracts mice; Requires anchroing.	Thompson and Palmertree (1967) Cook et al. (1970)
Wood fiber (Hydromulch)	Good moisture retention	Minimum erosion control in areas where frost heaving or excessive water flow occurs	Cook et al. (1970) Bartee (1964)
Petroleum products (asphalt emulsion)	Reduces evaporation, prevents soil crusting, remains intact 4-10 weeks	Repels water and insufficient water available to seeds, less effective in high intensity storm, absorbs high heat loads, test results generally poor	Chepil et al. (1963) Bement et al. (1961) Cook et al. (1970)
Latex emulsions		May limit water infiltration, expensive, poor erosion control	Chepil et al. (1963) Beard (1966)
Plastic films	Reduces evaporation and improves temperature regime	Expensive, doesn't justify advantages	Smith et al. (1967) Herbel (1971)

Table 9-8-3. (Continued)

Mulch Type	Advantage	Disadvantage	Studies or Review
Gravel, stones	Permanent, reduces erosion, reduces evaporation, increases infiltration of water	May retard seed germination	Chepil et al. (1963) Corey and Kemper (1968) Cook et al. (1970) Meyer et al. (1972)
Macerated paper	Satisfactory moisture retention	Not as long-lasting as straw or wood-fiber	Cook et al. (1970)

4. Fertilizer - Fertilizer probably will be used at minimum rates, based on preliminary soil surveys and chemical analyses of the soils in the area of interest. Further analyses will determine more specifically the nutrient and organic content of the soils. It is expected that no additional organic amendments will be required in areas where topsoil is stockpiled and replaced over the disturbed areas. In small disturbed areas where topsoil stockpiling is not practical, subsoil may be revegetated directly. In these areas, straw can provide additional organic material. If soil chemical analyses are not available, a fertilizer containing minimum nitrogen and phosphorus requirements will be applied. Fertilizers will generally be "fast releaser" forms since these are less expensive and can be applied at the time of seeding or during the first growing season. Care will be taken not to fertilize too heavily (above minimum requirements) since this may create conditions advantageous to undesirable species or cause grasses to out compete the forbs and shrubs.

5. Irrigation - Annual precipitation in the vicinity of Tract C-a varies from approximately 10-17 inches (See Section 3, Chapter 4) with higher amounts occurring at upper elevations. About one-half the precipitation occurs as snow. Sims and Redente (1974) have demonstrated that certain species in the vicinity can be successfully reseeded without supplemental irrigation or fertilizer. Since wide fluctuations in precipitation are common in arid regions, revegetation plans should not depend on average rates of rainfall for initial plant establishment, and irrigation must be considered as an alternative plan for extremely dry years.

Sprinkler systems will be used as necessary when drought conditions occur during spring and early summer, the critical periods for germination and establishment. Drip irrigation systems have received much attention but are expensive and less effective for the establishment of grasses and forbs. Irrigation water could be supplied from the shallow aquifer on site during the early stages of mine development. The quality of upper aquifer water is acceptable for germination and establishment of most species (range 540-2.850 ppm of soluble salts; average - 1,150 but the lower aquifer is generally too saline (range 630-3,640 ppm of soluble salts; average - 1,460).

6. Biotic Influences and Interactions - The palatibility of plant species in the revegetated areas may require fencing larger areas to exclude large herbivores (primarily feral horses and domestic livestock), but such fencing is not planned at this time. The fencing of small areas along roads and around buildings is not feasible. The size of the areas to be revegetated (e.g., approximately 40 acres per year on the disposal pile during Phase I) should minimize the concentrations of rodents and a rodent control program probably will not be necessary.

7. Management During Establishment - Seeded areas will be observed following initial revegetation procedures. Additional fertilizer and irrigation may be necessary in the second year of establishment. Control of undesirable plant species by prompt revegetation in disturbed areas and proper management should negate the need for herbicidal control. Any weed control prior to estabishment of vegetation can normally be done by mechanical methods such as tillage. Revegetated areas will be monitored to determine the success of the revegetation program (See Section 11, Chapter 7).

8. Schedule - As a result of Phase I mining of Tract C-a (six years), 360 acres of the processed shale disposal pile on 84 Mesa will require revegetation (Table 9-8-4). This will increase to approximately 4,000 acres over an expected 40-year period. Also, during Phase I approximately 200 acres are expected to require revegetation as a result of construction of roads, pipelines, and water control facilities. The need for revegetation of areas not related to the disposal area should not significantly increase in Phase II since most of these areas of disturbance will not be expanded. The areas disturbed during construction will be revegetated as soon as possible following completion of construction activities.

9. Summary and Conclusion - Much work has been done relative to revegetation in the arid West and in recent years investigators have studied the potential application of these procedures on the western slope. Extensive studies have been conducted in western Colorado to determine the most effective means of directly revegetating processed shale. Since RBOSP plans to construct an artificial soil profile on the disposal piles, the recent studies of processed shale are not directly applicable to the revegetation program for Tract

Table 9-8-4. The schedule of revegetation of areas resulting from open pit mining operations on the RBOSP Oil Shale Tract C-a.

	Acres of land requiring revegetation								
	1977	1978	1979	1980	1981	1982	1983	1984	1985
Overburden pile		45	30	25	13	12	12	12	30
Processed shale pile					17	23	23	23	20
Processing Facilities			1						
Soil Stockpile			20						
Roads				50					
Power Distribution Lines		1							
Pipeline			60						
Water Control Facilities		55	25	15					

C-a. This means that the disposal piles represent the most difficult revegetation task for RBOSP. This is due to the extent of disturbance resulting from disposal of processed shale and overburden and the limited available information concerning the potential of the artificial soil profile to eliminate adverse effects of processed shale.

Appropriate to the RBOSP revegetation program is the work by Sims and Redente (1974) which tested the adaptability of numerous plant species to conditions present in the Piceance Basin. This work investigated the response of plant species sown in pure stands without supplemental irrigation, mulch or fertilizer. The effects of competition which occur when a composite mixture of grass, forb and shrub species is sown is also unknown. Therefore, additional information appropriate for revegetation on Tract C-a is needed. The available technology seems sufficient to insure the likelihood of successful revegetation on the disposal piles but RBOSP has initiated an experimental revegetation program to investigate problems specific to revegetating the disposal piles planned for Tract C-a. This program will also gather additional data concerning those aspects of revegetation methodology which have not been studied in detail under conditions existing in the Piceance Basin.

The revegetation experimental program represents the initial step in the formulation of an optimum revegetation plan for RBOSP Tract C-a. The experimental results will provide a specific data base from which to evaluate and modify current methodology to further insure successful revegetation on Tract C-a.

B. Experiments

1. Objectives - The revegetation experiments being conducted on Tract C-a are designed to determine the following:

- Which species when sown in a composite species mixture are best adapted to the physical and environmental conditions existing on and near Tract C-a, in areas which will require revegetation.

- The effectiveness of several mulches in aiding establishment of the sown plant species and in reducing erosion in the plots.
- The effects of fertilizer applied at different time periods on the sown plant species
- The effects of aspect on the establishment of the sown species.

2. Methods

a. Schedule - Table 9-8-5 outlines the schedule of events for the three-year revegetation studies on Tract C-a. Fall field plantings will be made in three successive years starting in the fall of 1975.

b. Location of Test Sites - Location of the first year experiments (Sites R_1 and R_2) are presented in Figure 9-8-2. These sites are located in the southeast corner of the tract (T1S, R99N, Section 10) on opposing slopes along Wolf Ridge, between elevations of 7,100 and 7,200 feet (Figure 9-8-2). Natural slopes are about 15 percent, soils are relatively shallow (1 - 3 ft) fine sandy loams and very channery (platy) fine sandy loams of the Rentsac-Piceance complex (SCS, 1975). Trials in the two subsequent years will each utilize a single site on the slope having the more extreme drought conditions of the two original sites tested.

At a particular test site each of 16 treatments is applied at random to a 10 x 10 m plot and replicated in three complete blocks (Figure 9-8-3). Each plot is surrounded by a 3 m buffer zone. The total dimensions of a site sample are 55 x 165 m or 9,075 m^2 (= 0.91 ha or 2.24 acre per site). Within each 10 x 10 m plot, a minimum of three 1 m (3.3 ft) x 0.5 m (1.7 ft) subplots will be randomly established and marked permanently for subsequent data collection.

c. Seedbed Preparation - Native vegetation will be scraped from the two experimental plot sites prior to substrate mixing. Topsoil (about the upper six inches of the soil) and remaining subsoil is stockpiled separately. The underlying bedrock, consisting mostly of fractured calcareous sandstone, is broken to a minimum thickness of 24 inches. Subsoil and topsoil are then replaced and graded to approximately a 3:1 slope for sowing. This configuration closely approximates that of the currently designed disposal pile.

Table 9-8-5. Schedule of events for revegetation studies on Oil Shale Tract C-a Rio Blanco County, Colorado, 1975 through 1978

	1975						1976												1977												1978											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Site Selection	Δ																																									
Field Work																																										
Seedbed Preparation				Δ												Δ												Δ														
Planting				Δ												Δ												Δ														
Measurements of Plant Response to Treatments													Δ		Δ										Δ		Δ										Δ		Δ			
Soil Analysis																																										
Sample Collection				Δ												Δ												Δ														
Moisture Determination					Δ								Δ		Δ		Δ								Δ		Δ		Δ								Δ		Δ		Δ		
Meetings	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Reports																																										
Monthly	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Semi-Annual						Δ						Δ						Δ						Δ						Δ						Δ						Δ

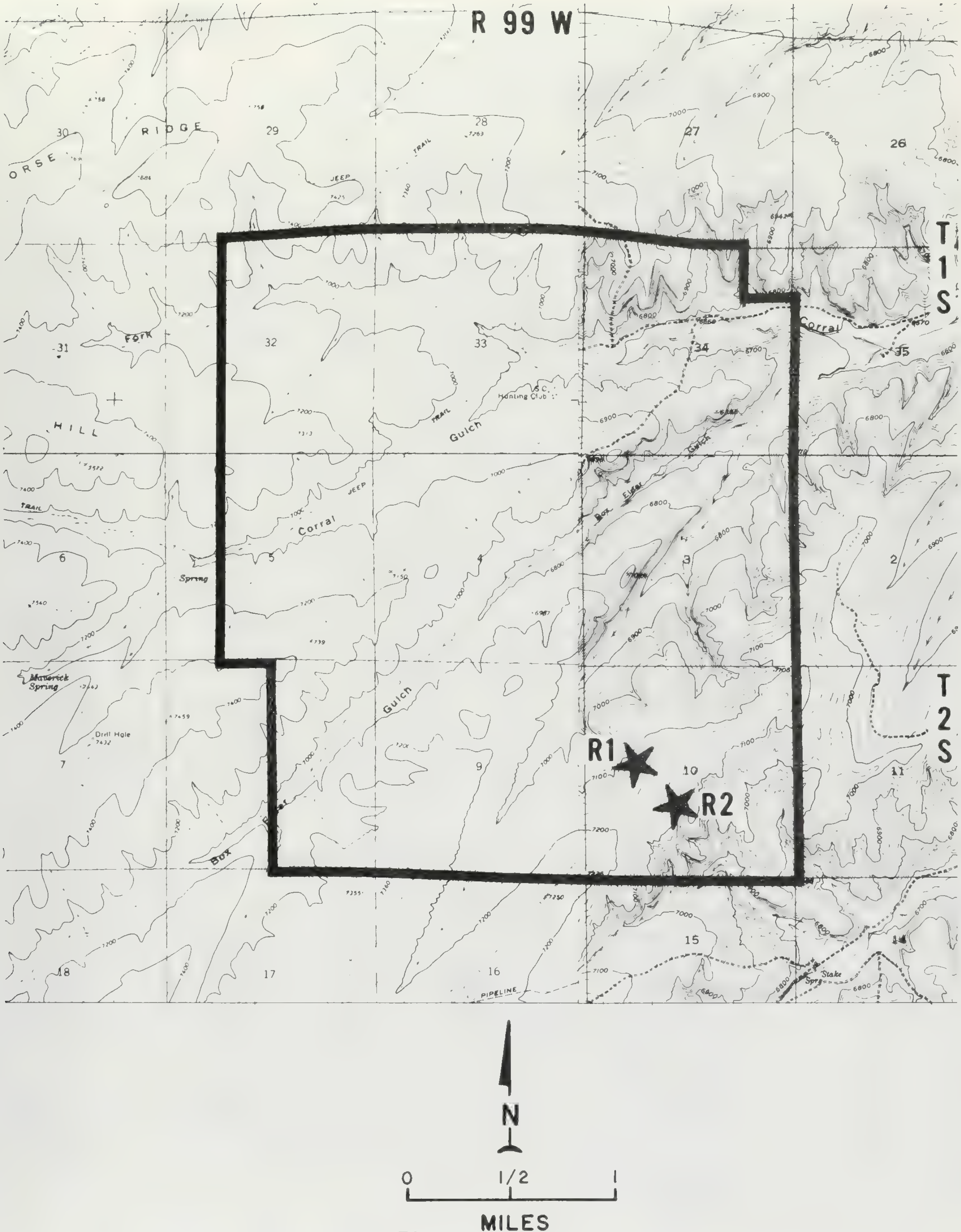


Figure 9-8-2

LOCATION OF REVEGETATION TEST PLOTS (R_1 and R_2)

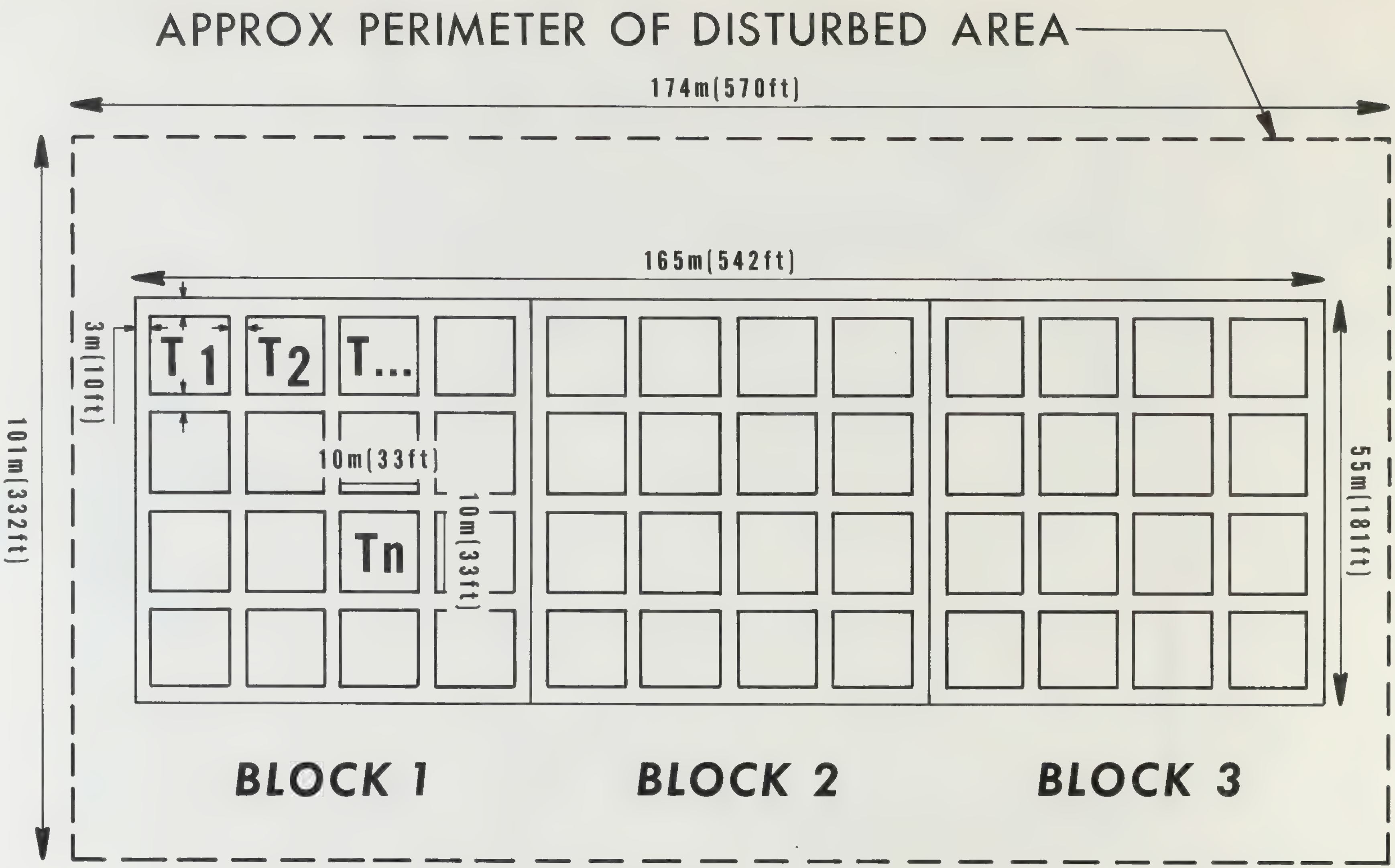


Figure 9-8-3

GENERALIZED PLOT LAYOUT FOR REVEGETATION PLOTS ON OIL SHALE LEASE TRACT C-a, RIO BLANCO COUNTY, COLORADO, 1975 - 1977. SIXTEEN TREATMENTS (T1 - T16) ARE REPLICATED IN THREE COMPLETE BLOCKS. BLOCKS AND TREATMENT PLOTS ARE RANDOMLY LOCATED.

As a result of the site preparation process, an appropriate perimeter is disturbed around each site, thus bringing the total area of disturbance per site to 1.7 ha (4.3 acre) or 3.5 ha (8.6 acre) for two sites (R_1 and R_2) (Figure 9-9-3.

d. Seeding - A composite mixture of grasses, forbs and woody plants (Table 9-8-6) is drilled using a conventional grassland drill equipped with depth bands and a single-seed box and agitator. This drill places the seeds in rows 5 - 7 inches apart. The suitability of each species as wildlife food and cover, as soil stabilizers, and for drought tolerance is presented in Table 9-8-6.

Approximately 15.7 lb of seed per acre is sown, with grasses and nongrasses (forbs and woody plants) sown in approximately equal proportions. For the 1975 tests, the 8.1 lb per acre of grass seed equals 6.5 lb of PLS per acre (17 PLS per square foot). The amount of PLS could not be determined for all forbs and shrubs at the time of seeding since native seed was used. The PLS per lb of the native forbs and shrub is expected to be equal to or less than that of the grass species. The PLS of the seed will vary from year to year.

e. Treatments - For the 1975 test a total of 16 treatments were applied using all possible combinations of the following variables:

Mulch Type and Application

- No mulch
- Hydromulch with wood fiber
- Straw mulch followed by crimping
- Straw mulch with netting

Fertilizer Application (10-5-5 applied at a rate of 160 lb/acre; this may be revised as soil chemical analyses are available).

- No fertilizer

Table 9-8-6. Plant species suitability and recommended sowing rates (lbs/acre) of bulk seed for species utilized in revegetation experiments on Oil Shale Tract C-a, Rio Blanco County, Colorado.

Species	Suitability Rating[a]	1975 Seeding Rates (lbs/acre)
Grasses		
Luna pubescent wheatgrass (*Agropyron trichophorum* var. *Luna*)	2,4,6,8,9	1.5
Rosana western wheatgrass (*Agropyron smithii* var. *Rosana*)	4,5,8,9	1.5
Sodar streambank wheatgrass (*Agropyron riparium* var. *Sodar*)	3,5,8,9	1.5
Indian ricegrass (*Oryzopsis hymenoides*)	2,4,5,7,9	0.6
C-43 basin wild rye (*Elymus cinereus* var. *C-43*)	2,4,5,7,11	1.5
Green needlegrass (*Stipa viridula*)	2,5,7	1.5
Forbs		
Lewis flax (*Linum lewisii*)	2,5	0.5
Lutana cicer milkvetch (*Astragalus cicer* var. *Lutana*)	6,11	0.5
Utah sweetvetch (*Hedysarum utahensis*)	2,5	0.5
Madrid yellow sweetclover (*Melilotus officinalis* var. *Madrid*)	2,4,5,9,11	0.5
Rocky Mountain penstemon (*Penstemon strictus* var. *bandera*)	3,5,9	0.5
Scarlet globemallow (*Sphaeralcea coccinea*)	3,5,9	0.5
Shrubs		
Big sagebrush (*Artemisia tridentata*)	2,5,9,10,11	0.2
Little rabbitbrush (*Chrysothamnus viscidiflorus*)	2,4,5,9,11	0.2
Bitterbrush (*Purshia tridentata*)	1,5,9,10,11	1.0
Mountain mahogany (*Cerocarpus montanus*)	1,5,10	0.5
Fourwing saltbush (*Artiplex canescens*)	1 (seeds), 3,4,5,9	1.0
Winterfat (*Eurotia lanata*)	1,5,10	0.5
Rubber rabbitbrush (*Chrysothamnus nauseosus*)	3,5,9,10,11	0.5
Squaw bush (*Rhus trilobata*)	2,4,5,9,10,11	0.5

Table 9-8-6. (Continued)

Species	Suitability Rating[a]		1975 Seeding Rate (lbs/acre)
Trees			
Utah juniper (Juniperus osteosperma)	3,5,9,10,11		0.1
Pinyon pine (Pinus edulis)	3,5,9,11		0.1
		Total	15.7

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[a] Suitability ratings are:

1	highly palatable	7	bunch grass
2	moderately palatable	8	sod grass
3	unpalatable	9	drought resistant
4	soil stabilizer	10	browse
5	native to Colorado[b]	11	cover for game
6	introduced species		

[b] Underlining indicates species observed on site as part of the environmental baseline studies (See Section 3-7.1, p.).

- Fertilizer at time of sowing (fall)
- Fertilizer at beginning of first full growing season
- Fertilizer at time of sowing and at beginning of first full growing season

Revegetation experiments to be initiated in the fall of 1976 and the fall of 1977 are designed to essentially duplicate those initiated in 1975, except that a layer of Paraho processed oil shale approximately six inches in thickness will be placed over the bedrock and below the simulated overburden.

3. Data - The following plant response parameters will be measured for each treatment: (1) number of emerged seedlings per plot, (2) number of surviving seedlings per plot, (3) above ground biomass, (4) percent cover and (5) vigor.

Table 9-8-7 gives the season of measurement for each parameter and the taxa involved. Data collection will begin in spring of 1976.

4. Summary and Conclusions - The revegetation experiments, outlined above, constitute the present plan for revegetation. Additional information concerning the details of these experiments is available (RBOSP - Progress Report 4 - Summary, 1975). Results of these tests should further refine the revegetation plan with regard to more specific seed mixtures for different site conditions, the most effective mulches, and the best time for fertilization. In addition, the trials will indicate how well vegetation can be established without supplemental irrigation. Most importantly, the use of processed shale in 1976 will test the feasibility of using a crushed rock layer to stop upward migration of salt into the plant rooting zone. Although only one substrate configuration is presently being tested, this does not preclude the possibility that additional substrates will be tested if new developments and technology so warrant.

As this three year study progresses, the results will be reviewed in consultation with the Area Oil Shale Supervisor to determine the need for additional studies.

Table 9-8-7. Plant response parameters measured in revegetation experiments on Oil Shale Tract C-a, Rio Blanco County, Colorado, 1976-1978.

Parameter	Time of Measurement	Taxa Involved
Number of emerged seedlings per plot	first spring following fall planting, i.e., beginning of first growing season	each planted species
Number of surviving seedlings	end of first growing season	each planted species
Above-ground biomass (dry wt.)	end of third growing season	total seeded species, total alien species, individual seeded species contributing bulk of biomass
Percent cover	end of each growing season	each species
Vigor	end of each growing season	each planted species

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CHAPTER 9

SOLID WASTE CONTROL

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 9

SOLID WASTE CONTROL

The Solid Waste Control Plan describes the expected disposal methods for solid wastes, excluding processed shale and overburden (see Section 7), which are produced during both the construction and operation phases of the project. These solid wastes include process (catalysts and water treatment chemicals) and nonprocess (paper, wood, metal, etc.) related waste.

The primary regulations relating to solid waste disposal in Colorado are contained in Chapter 36, Article 23, Colorado Revised Statutes, 1963, as amended. The Colorado Department of Health is charged with administering these regulations. Rio Blanco will comply with the above law and in addition to all applicable Federal and local laws, rules and regulations.

9.1 NONPROCESS WASTES

A. Composition and Quantity - During construction and operation of the project nonrecyclable wastes will be produced in the mine, processing facility and processed shale and overburden disposal areas. The estimated composition of this waste during the operational phases is as follows:

Material	Weight Percent
Paper	28
Organic Waste	7
Glass	8
Nonrecyclable metals	14
Wood	7
Plastics	8
Rubber and leather	14
Textiles	4
Laboratory waste	8
Miscellaneous inorganics	2
Total	100

Wood and nonrecyclable metals are expected to represent much higher percentages of the total waste during construction. A rough estimate of the quantity of waste generated by the project has been made based on manpower projections. Estimates for Phase I are two (2) tons per day of solid waste during construction and one (1) ton during operation. Phase II estimates are six (6) and three (3) tons per day of solid waste for construction and operation, respectively.

B. Collection and Transport - Nonrecyclable waste will be collected in covered steel containers placed conveniently around the project area. The capacity of the containers will vary from 1 to 5 cubic yards depending on the nature and volume of waste. A collection-compactor truck will pick up the waste on a regular schedule and transport it to the sanitary landfill located at the processed shale and overburden disposal site.

Separate containers, suitably marked, will be provided for recyclable materials. Vendors will probably call at the project to pick up some recyclable material. That material not picked up by vendors will be transported to recycle centers by available project transportation.

C. Disposal - All solid waste that is not recycled will be disposed of in an approved sanitary landfill. RBOSP will prepare the "Engineering Data" required by Colorado Department of Health regulations and apply to the Rio Blanco County Board of Commissioners for a Certificate of Designation to operate a solid-waste disposal site. The detailed engineering will be accomplished during the final design of the project so that the disposal site can be placed in operation when construction of the facility begins.

The excavated trench method of operation will be employed to facilitate compaction and cover, together with temporary fencing to minimize scattering of paper and trash by wind. Present planning contemplates that the solid-waste disposal operation will be conducted at the same location as the processed shale disposal operation. When processed shale disposal commences, the solid waste disposal trenches will be constructed within the compacted processed shale. This expedient will minimize the land disturbed for the actual disposal, eliminate the need for construction and maintenance of separate access roads and storm diversion facilities, and require less equipment, fuel and manpower.

9.2 PROCESS WASTES

A. Phase I - The principal solid wastes (other than processed shale) produced in the Phase I processing facility are small amounts of lime sludge and spent zeolite water softening resins from the water treatment system. The estimated quantity of these materials for Phase I - Stage 1 are:

Spent zeolites	600 lb/yr
Lime sludge (water-free solids)	60 lb/hr

The estimated composition of the lime sludge is as follows:

	Weight %
$CaCO_3$	3.2
$Mg(OH)_2$	0.7
SiO_2	0.1
H_2O	96.0
	100.0

The lime sludge and spent zeolites will be disposed of with the processed shale. No adverse environmental effects are expected since the lime sludge zeolites comprise a very small fraction of the total quantity of material disposed of in the processed shale and overburden pile. Quantites of lime sludge and spent zeolites are doubled during Phase I - Stage 2. Disposal will be with processed shale.

B. Phase II - In addition to lime sludge and spent zeolites from the water treatment system, the Phase II processing facility will generate a certain amount of spent catalysts from hydrotreating, sulfur and hydrogen plants. Table 9-9-1 lists the expected solid wastes and estimated quantities.

Table 9-9-1

PHASE II PROCESSING FACILITY SOLID WASTES

Process Unit	Solid Waste Description	Approximate Quantity* TPY
Naphtha Hydrotreater	Spent hydrotreating catalyst	36
	Proprietary Solid	72
Gas Oil Hydrotreater	Spent hydrotreater catalyst	157
	Spent hydrotreater catalyst	130
	Proprietary solid	768
Hydrogen plant		
Shift conversion	Spent CO shift catalyst	40
Methanation	Spent CO methanation catalyst	5
Sulfur Recovery		
Claus Unit	Spent oxidation catalyst	40
Tail Gas Unit	Spent hydrogenation catalyst	25
Water Treating	Spent zeolites	2-1/2
	Lime sludge	63,291

*Average over catalyst life

The spent zeolites and lime sludge will be disposed of with the processed shale in the processed shale and overburden disposal piles. To the extent possible, the spent catalysts will be recycled. Preliminary information from vendors indicate that all the catalysts, with the exception of the proprietary solids used in the naphtha and gas oil hydrotreaters, can be recycled.

The licensor for the hydrotreating processes indicates that the spent catalyst could be disposed of in the processed shale and overburden disposal piles, without harmful environmental effects, but supporting data is not yet available. Therefore, present plans are to store the spent hydrotreating catalysts in impermeable, lined bunkers near the processing facility until the leaching effects of the catalyst are further studied, and a suitable technique for permanent disposal can be devised.

CHAPTER 10

AESTHETICS

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 10
AESTHETICS

The principal aesthetic value of Tract C-a and its environs is the landscape, which is characterized by rolling hills with flat-topped ridges and rounded canyon walls dropping steeply 100 to 300 feet into narrow, flat-bottomed valleys. Aesthetic values were considered in planning all facilities and operations. However, aesthetic guidelines could not always prevail because of economic constraints and conflicting environmental requirements. Criteria used to minimize the visual impact of the project and preserve scenic values are discussed in the following paragraphs.

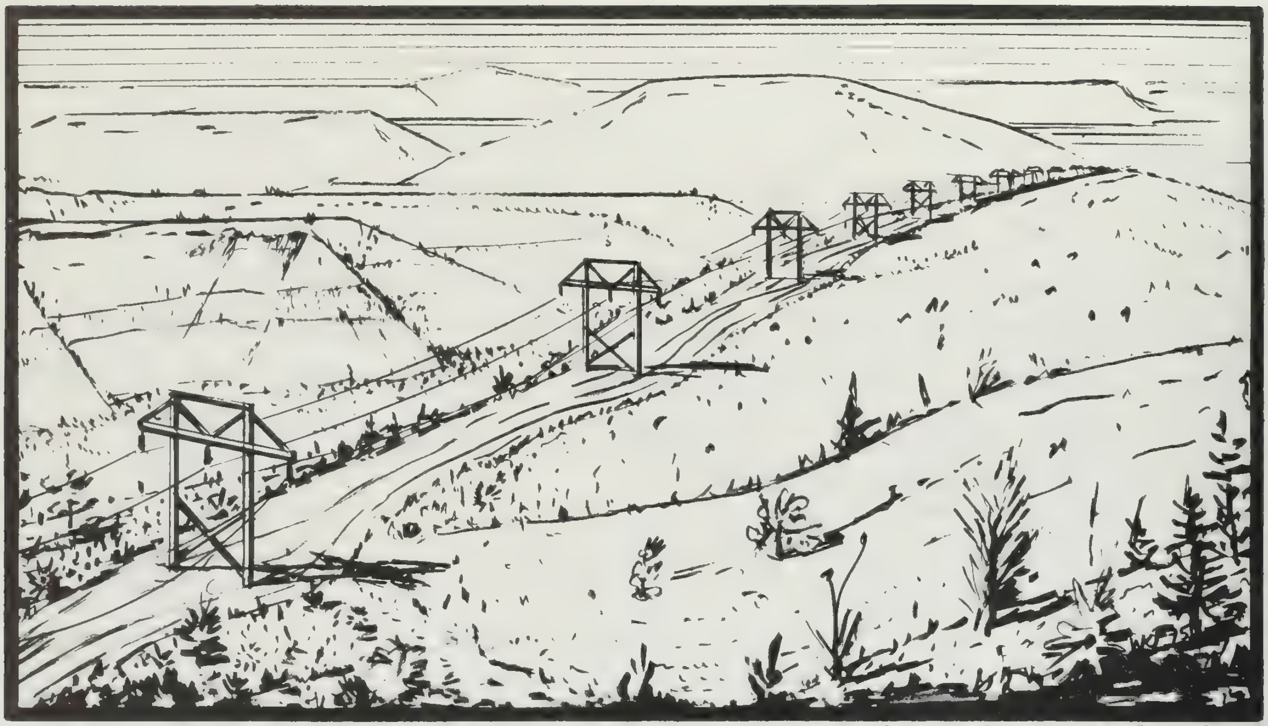
10.1 LOCATION

The visual impact of engineering features is greatly affected by their location and surroundings. The following concepts will be applied in minimizing this impact:

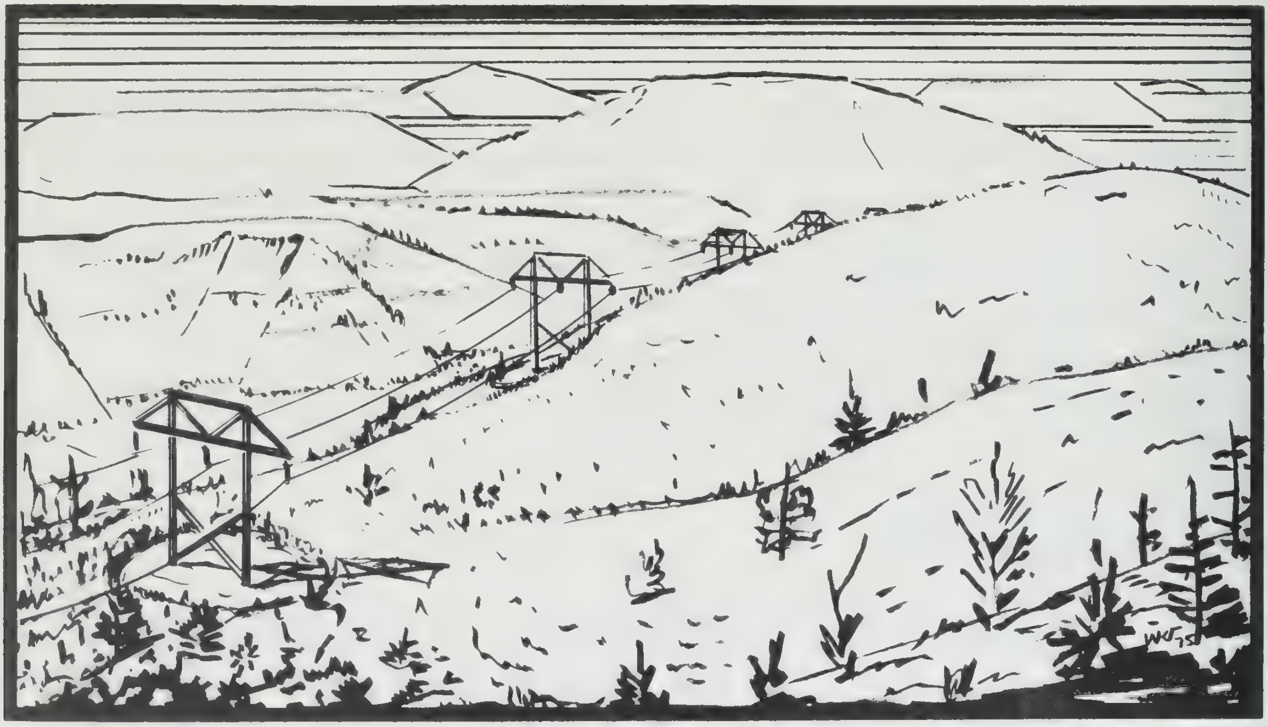
- Make outlines as nearly parallel to natural ground lines as possible.
- Locate transmission lines and pipelines so that extensive clearing will not be required.
- Locate transmission lines so that they will cross ridges in natural depressions, when possible (see Figure 9-10-1).
- Locate pipelines to avoid sidehill cuts.
- Minimize land disturbance through multiple-use corridor concept.

10.2 MATERIALS AND COLOR

Exposed construction materials will be selected or painted to reduce their visual impact. Bright colors and bare galvanized steel will be avoided where



Poor Location and Excess Clearing



Good Location with Minimum Stripping

Figure 9-10-1

POWER LINE ROUTING AND CONSTRUCTION

possible. Processed shale will be covered with overburden rock and soil (and, ultimately, vegetation) to blend with the natural background.

10.3 SHAPE

Major processing structures and buildings have distinctive shapes, and little can be done to alter these shapes without interferring with their economical functioning. However, in earthmoving activities and disposal pile construction, shape will be used as a means of reducing visual impact, as follows:

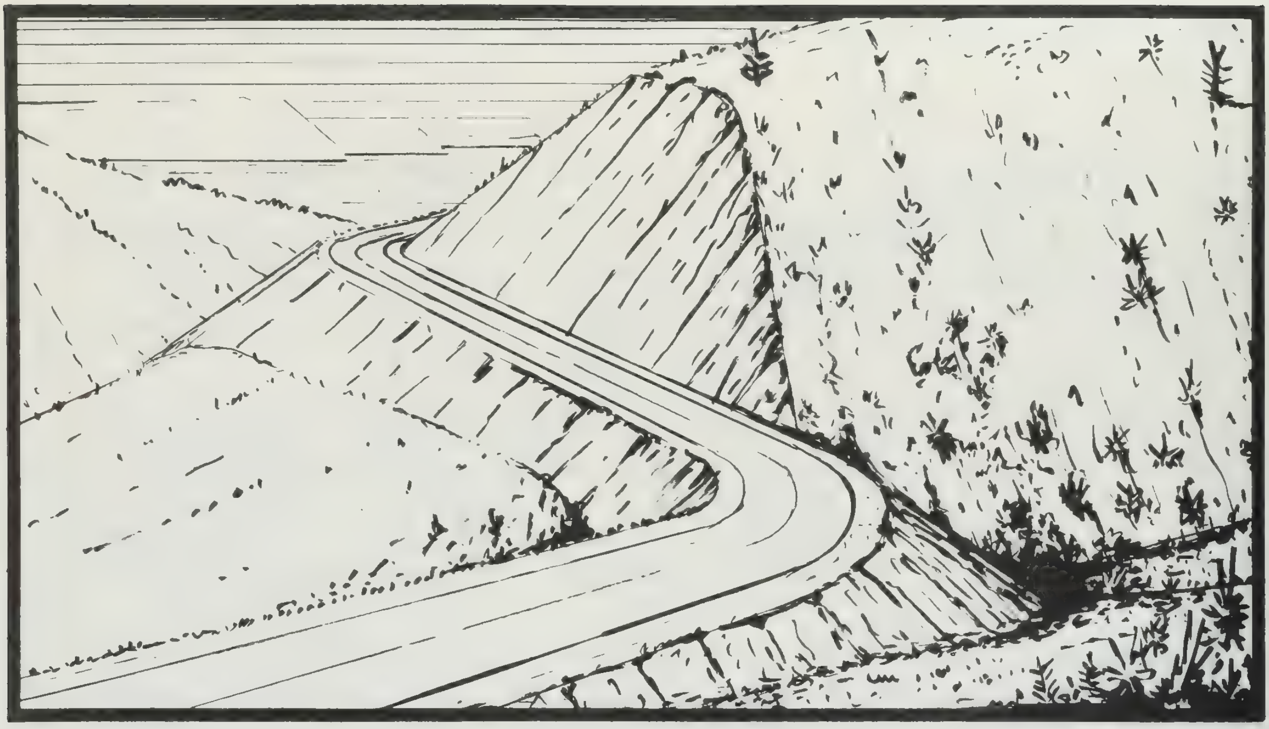
- Changes from formal to natural lines will be made gradually.
- Slope rounding will be used to blend man-made slopes into the natural ground shape (see Figure 9-10-2).
- Benches and terraces will be used to break up long slopes (see Figure 9-10-3).
- Natural looking ridges and valleys will be constructed in large disposal piles (see Figure 9-10-4).

10.4 VEGETATION

The ultimate success in minimizing visual impact will depend largely on the success of the revegetation program. Contrasting vegetation types will be used to enhance the appearance of the overall project. However, any new vegetation will be chosen to blend with existing vegetation.

Movements of processed shale and earth will be coordinated with revegetation efforts to aid in the control of sedimentation and erosion and in the restoration of vegetation. Such coordination of efforts will contribute to the development of aesthetically pleasing designs and facilitate operation and maintenance.

Cuts and embankments, properly constructed and revegetated, will soon become part of the landscape, requiring minimal attention and maintenance.



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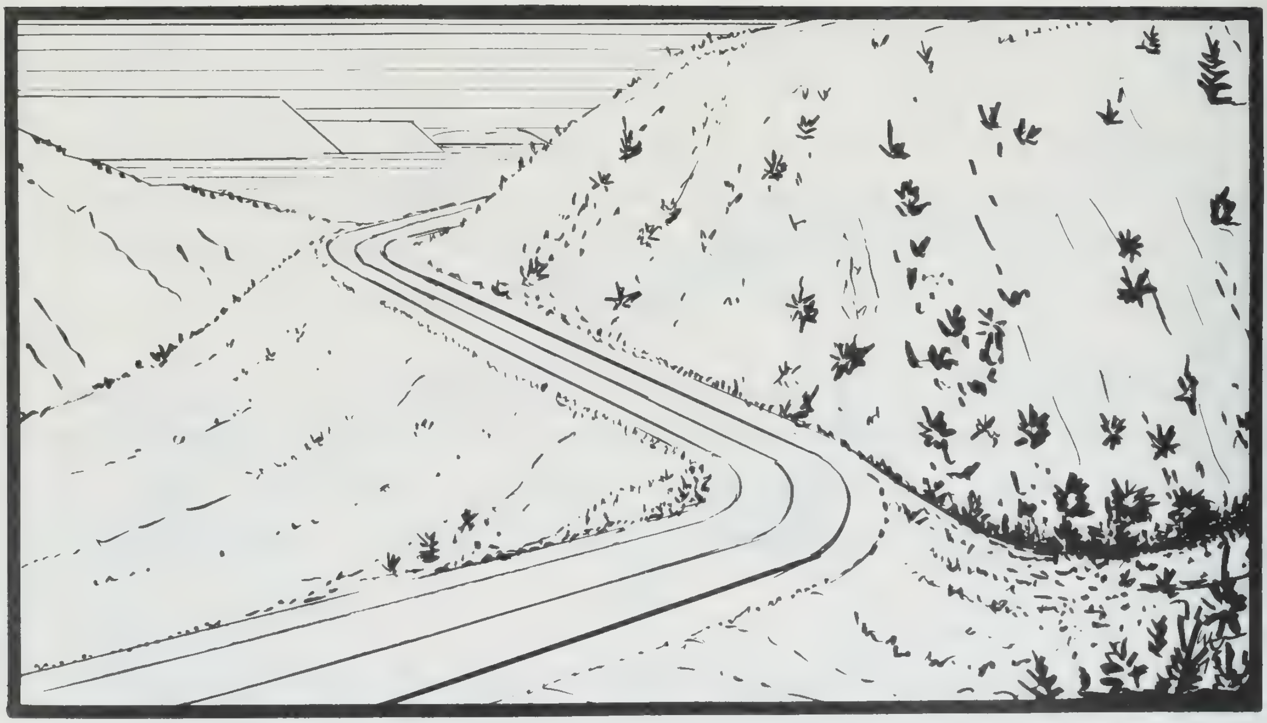
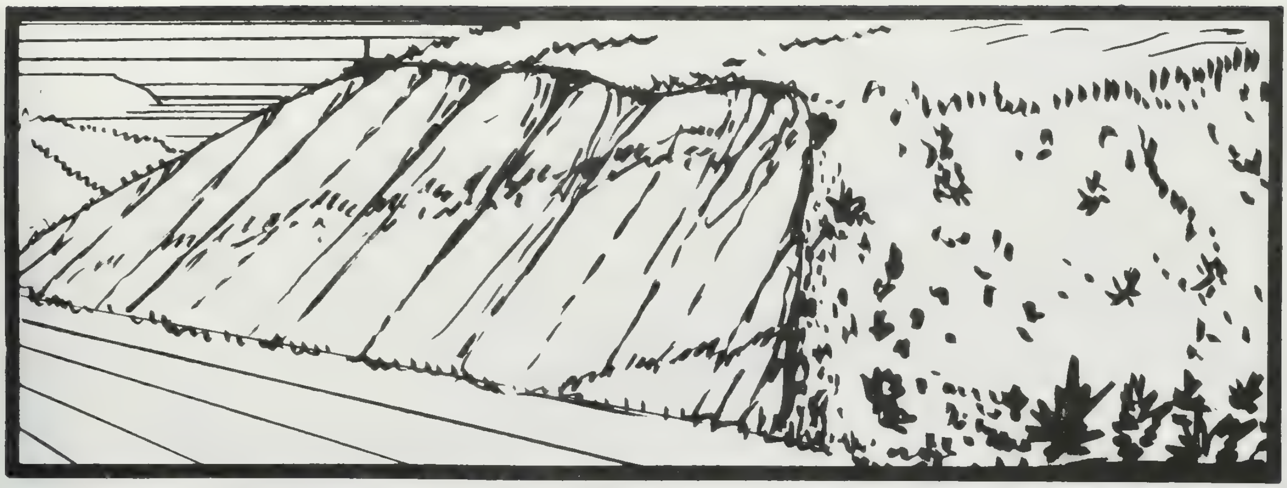


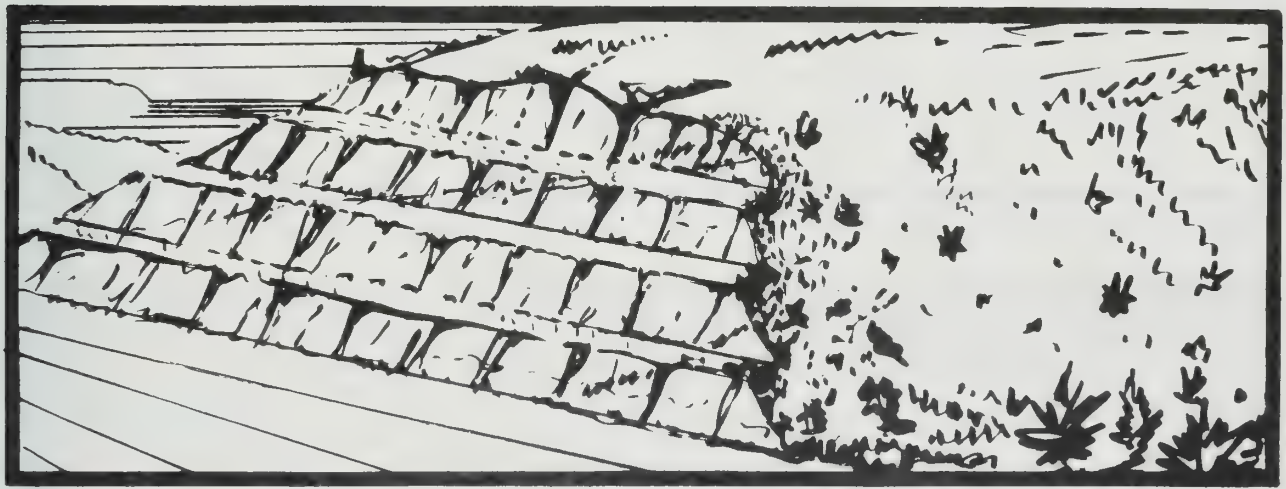
Slopes Rounded and Revegetated

Figure 9-10-2

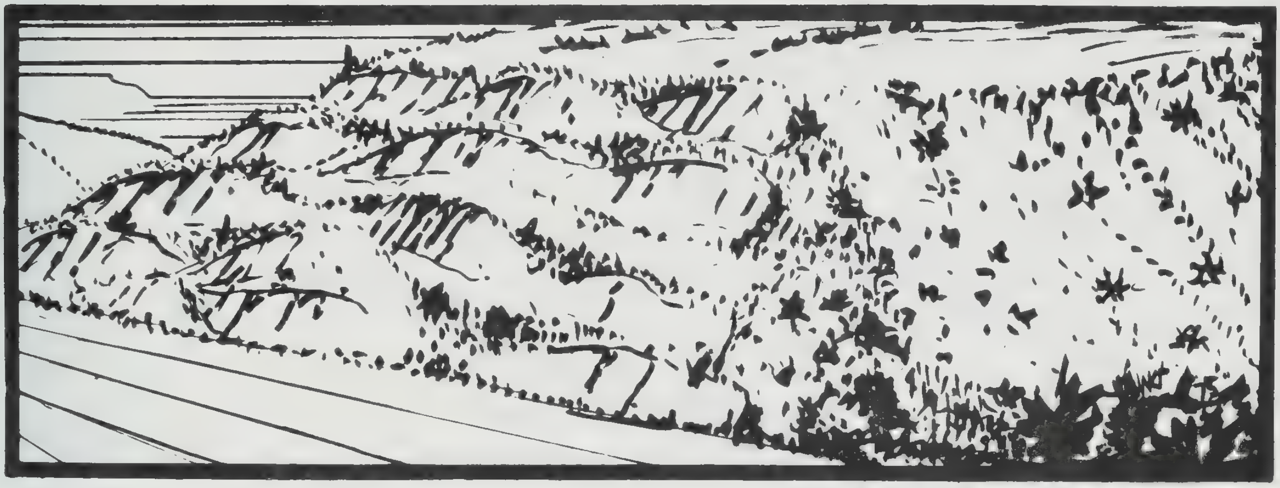
SLOPE ROUNDING



Untreated Slope



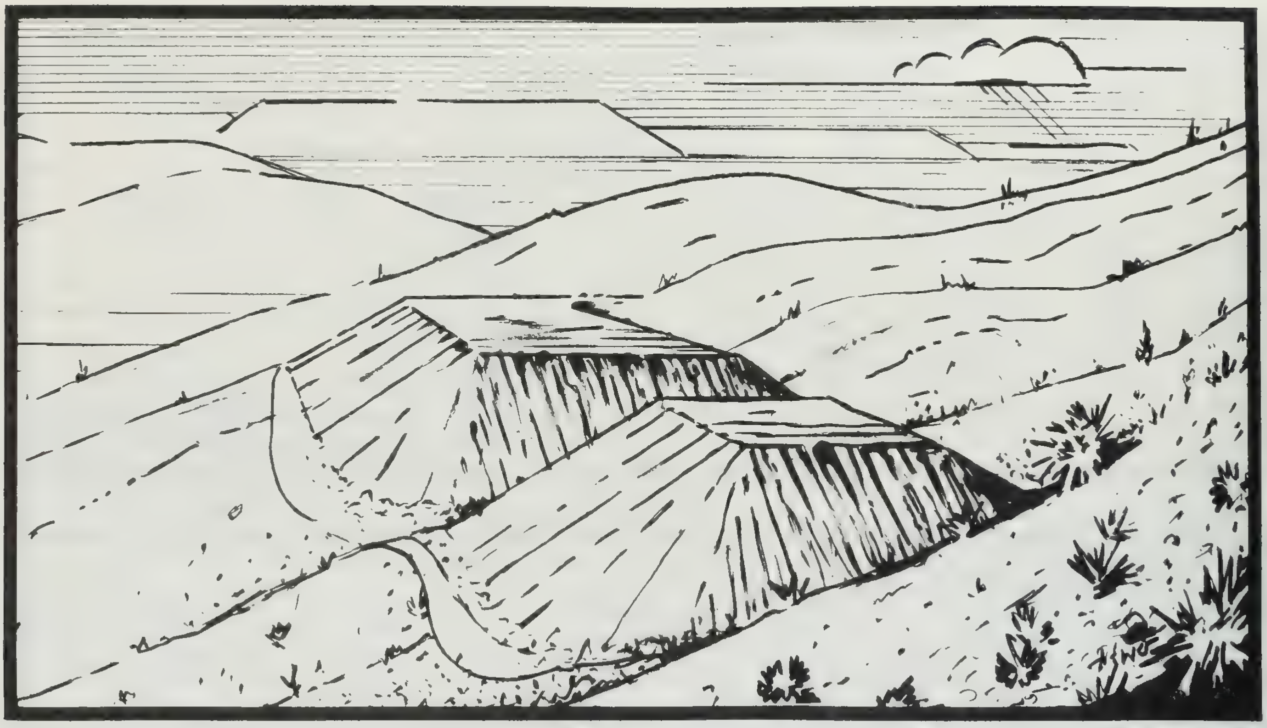
Formal Benching



Informal Benching

Figure 9-10-3

BENCHING AND TERRACING



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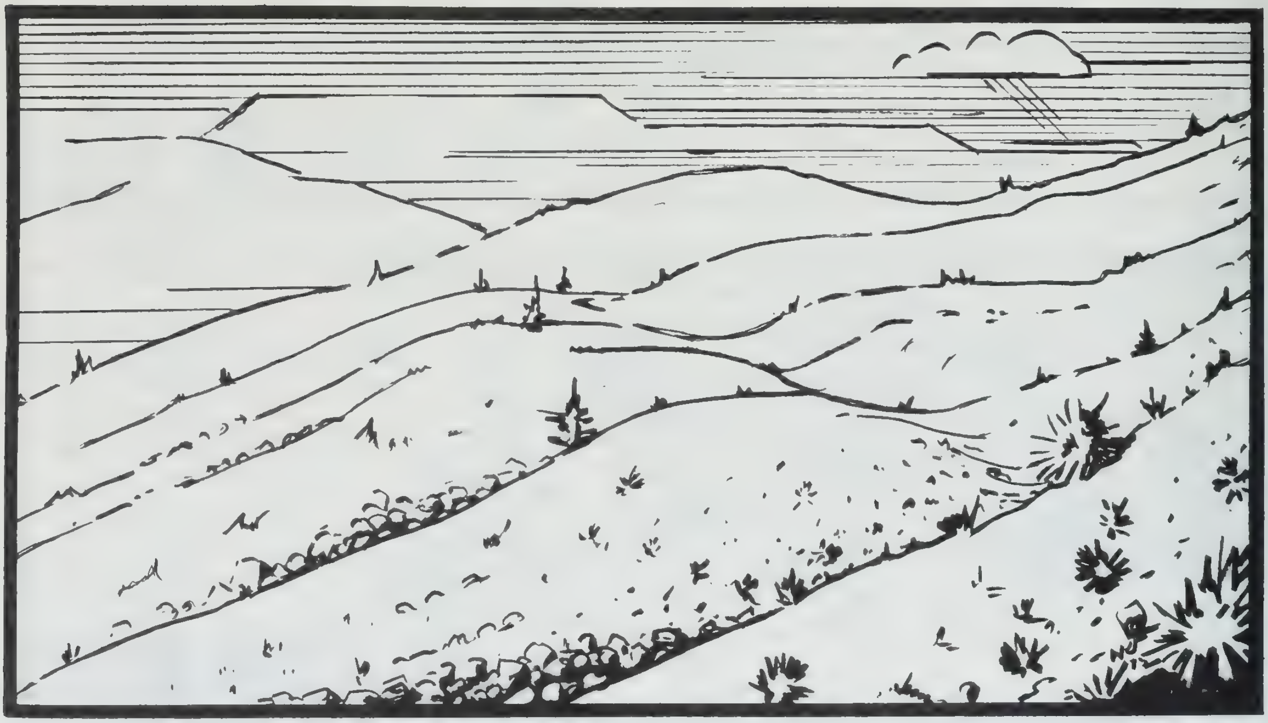


Rounded and Revegetated

Figure 9-10-4

DISPOSAL PILE SHAPING

10.5 CLEARING

The cleared right-of-way for electric transmission lines and pipelines will produce, by far, the greatest aesthetic impact. The scar left by a bare area cleared for a right-of-way is difficult to remove. Therefore, such cleared areas will be avoided as much as possible.

In the Tract C-a area several techniques will be employed to minimize the visual impact. Most of the vegetation consists of types that have limited height. In areas where sagebrush predominates, there is little need to clear a wide, straight path for a transmission line.

In areas where pinon juniper vegetation exists, the same technique can be used. Transmission lines will be constructed with sufficient clearance between conductor cables and vegetation. Topping or removal of tall trees may be required in some cases.

When clearing a right-of-way, all vegetation possible will be left undisturbed. "Dozed" paths will not be permitted. Only the larger vegetation will be removed.

10.6 SIGNS

Signs will be of rustic appearance, constructed to blend with the natural landscape. They will not, however, be camouflaged so that the public cannot see them and heed their warnings.

Signs on State and county highways will comply with the standards of the respective State or county highway agency. All other road signs will be designed in accordance with Bureau of Land Management Standard No. 9132.

CHAPTER 11

FISH AND WILDLIFE MANAGEMENT

CHAPTER 11

FISH AND WILDLIFE MANAGEMENT PLAN

This chapter describes the steps Rio Blanco Oil Shale Project will take to: avoid, or where avoidance is impracticable, minimize damage to wildlife habitat; increase production on Tract C-a and adjacent habitats to compensate for habitat unavoidably removed or damaged; monitor known and possible effects of oil shale development; monitor mitigative procedures and habitat enhancement procedures; and control employee or contractor-caused human disturbance. It is important to make clear at the outset that this has had to be done within the legal limits of RBOSP authority and jurisdiction. Nonetheless, RBOSP recognized that the effects of Tract C-a development will extend beyond tract boundaries and, that to some degree, the existence of such legal constraints may limit the effectiveness of the management plan described herein. For example, the use of deer habitat enhancement areas by off-road vehicles, such as snow machines, could render such enhancement completely ineffective. Yet the lease apparently prohibits the lessee from imposing the kind of regulations needed to control such activities. In general, this fish and wildlife management plan will achieve maximum effectiveness only if it is applied beyond the present limits of RBOSP authority through cooperation with the appropriate state and federal agencies. RBOSP will coordinate all activities through the Area Oil Shale Office as stipulated in the lease.

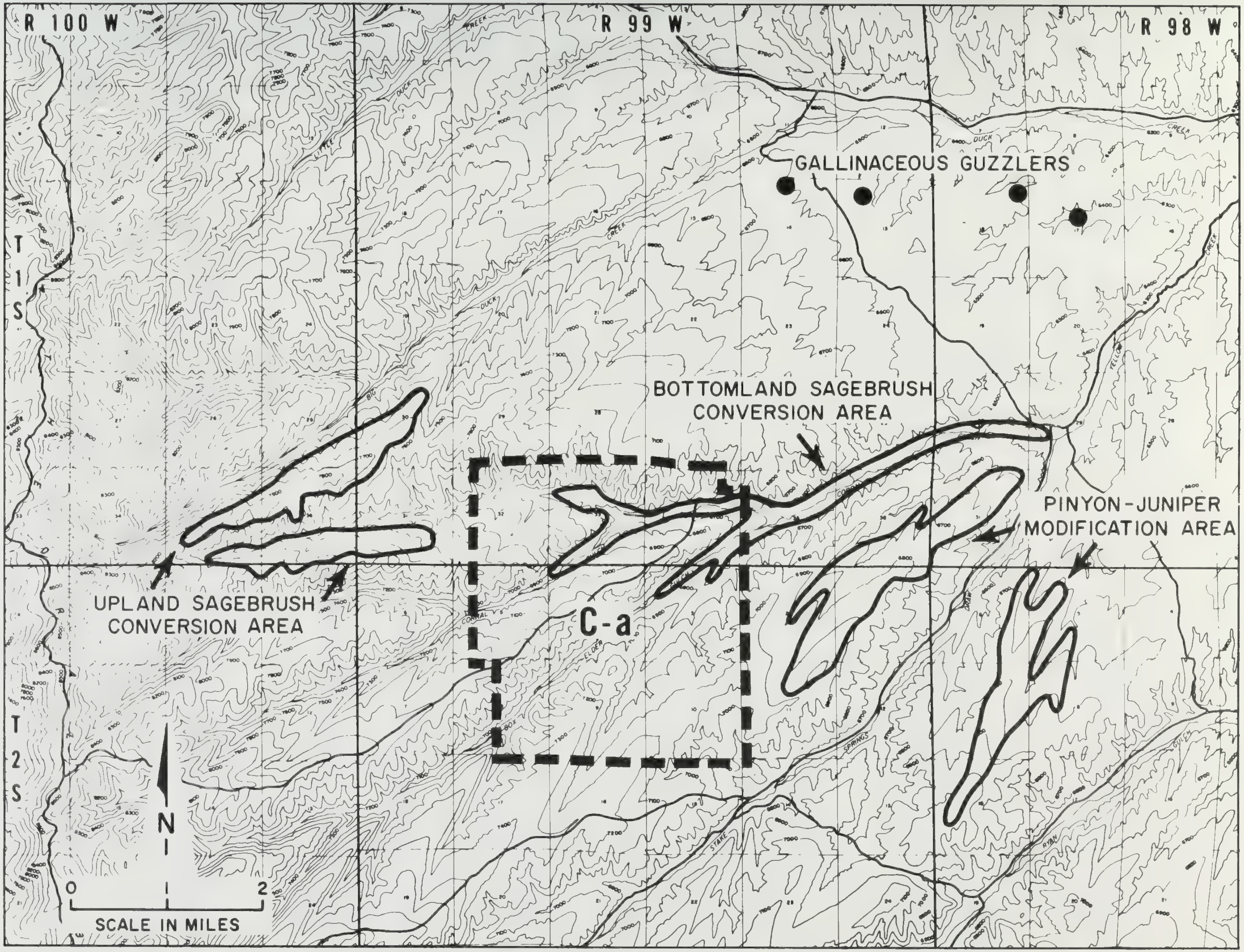
An RBOSP Supervisor will be appointed and will be responsible for protecting wildlife values in the Tract C-a area. He will direct certain portions of the Wildlife Management Plan (e.g., habitat enhancement) and serve as a quality assurance function in wildlife concerns. This individual will represent RBOSP in wildlife-related matters and interact with state and federal agencies, however, the primary contact will be the Area Oil Shale Supervisor.

Specific impact related mitigation will consist primarily of disturbance control measures applied to construction or operating practices. These and rehabilitation (revegetation) measures are provided in other chapters of

Wildlife habitats will be manipulated in an attempt to increase productivity, and hence carrying capacity of lands adjacent to those areas to be rendered unproductive. RBOSP plans to take a two-step approach in satisfying lease stipulations governing the habitat enhancement.

The limits of RBOSP authority represent a major difficulty in developing habitat enhancement measures which will effectively mitigate the effects of oil shale development on Tract C-a. Although these effects may well extend beyond the tract boundaries, RBOSP's authority to initiate habitat enhancement does not, thus the following two-stage approach will be taken. In the early stage of development, habitat enhancement measures will be confined to areas controlled by RBOSP, primarily to the southeastern one-quarter of the tract furthest from development activities. The vegetation types most amenable to manipulation for increased wildlife productivity (such as large acreages of dense pinyon-juniper, upland sagebrush, and lowland sagebrush) are of very limited distribution on the tract. Nonetheless, existing acreages of these types should be sufficient to allow mitigation of habitat losses during the early stage of development. During later stages of development, it will not be possible to effectively mitigate negative effects unless the same habitat enhancement procedured recommended for the tract are applied off-tract assuming their success on tract. During the first stages of development, then, the groundwork must be laid in consultation with the appropriate state and federal agencies for extending provisions of the Wildlife Management Plan beyond the Tract C-a perimeter. The general areas in which this extension of habitat enhancement would be most effective are outlined in Figure 9-11-1. A basic assumption of this Wildlife Management Plan is that such a two-stage process of habitat enhancement can and must be applied if the negative effects of Tract C-a development are to be mitigated to the maximum feasible degree.

Initially land disturbance associated with Phase I and Transition Phase operations will be far less in total acreage as compared to the proposed Phase II operations plans. Thus RBOSP can, within its legal limits, utilize


R 100 W
R 99 W
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T 1 S
T 2 S
GALLINACEOUS GUZZLERS
BOTTOMLAND SAGEBRUSH CONVERSION AREA
PINYON-JUNIPER MODIFICATION AREA
UPLAND SAGEBRUSH CONVERSION AREA
C-a
N
0
2
SCALE IN MILES

Figure 9-11-1

AREAS IN WHICH HABITAT ENHANCEMENT EXTENSION COULD BE MOST EFFECTIVE and enhance existing lands on Tract C-a in the early phases of development. This plan will not interfere with existing mining plans which place the open pit in the northwest corner of the tract progressing in a southeastern direction. When the extent of mine land disturbance outstrips available enhancement land on Tract C-a, this will necessitate a move into off-tract areas. Prior to this changeover, RBOSP, in cooperation with the land owner, will satisfy all legal obligations necessary to the transaction. Such an approach will provide compliance by RBOSP with a lease stipulation regarding habitat loss and resulting enhancement. In addition, when backfilling commences, revegetation will provide additional habitat in response to those lost.

Pinyon-juniper will be modified through very selective chaining to open dense tree canopies and create zones of vegetation transition in order to increase productivity and wildlife diversity. Slash and woody debris will be used where appropriate in the construction of brush piles to improve structural habitat for cottontails and other wildlife. These enhancement procedures will avoid concentrating animals along roadsides or other hazardous areas.

Discrete areas of bottomland sagebrush will be removed by railing and roto-beating to increase forage production for livestock. Deer may also use the increased forage of the treated areas.

If needed, certain limited areas of dense upland sagebrush will be modified during Phase II. A roto-beater will thin specific sagebrush stands by cutting narrow, irregular swaths. Again, the intent is to increase production and diversity.

Guzzlers will be installed where needed to provide a permanent supply of drinking water for wildlife. Considerations of other surface water developments are also discussed for wildlife and cattle.

Perhaps one of the most serious potential impacts to wildlife is the secondary effect of increased human activity in the development area. To help protect wildlife, and reduce the magnitude of this impact, human activity will be regulated within the limits of RBOSP responsibility and legal jurisdiction.

Various categories of human disturbance problems and planned mitigation are presented. They are: 1) vehicle-animal collisions, 2) legal wildlife harvest, 3) illegal wildlife harvests, 4) off-road vehicle use, and 5) harassment by humans and companion animals.

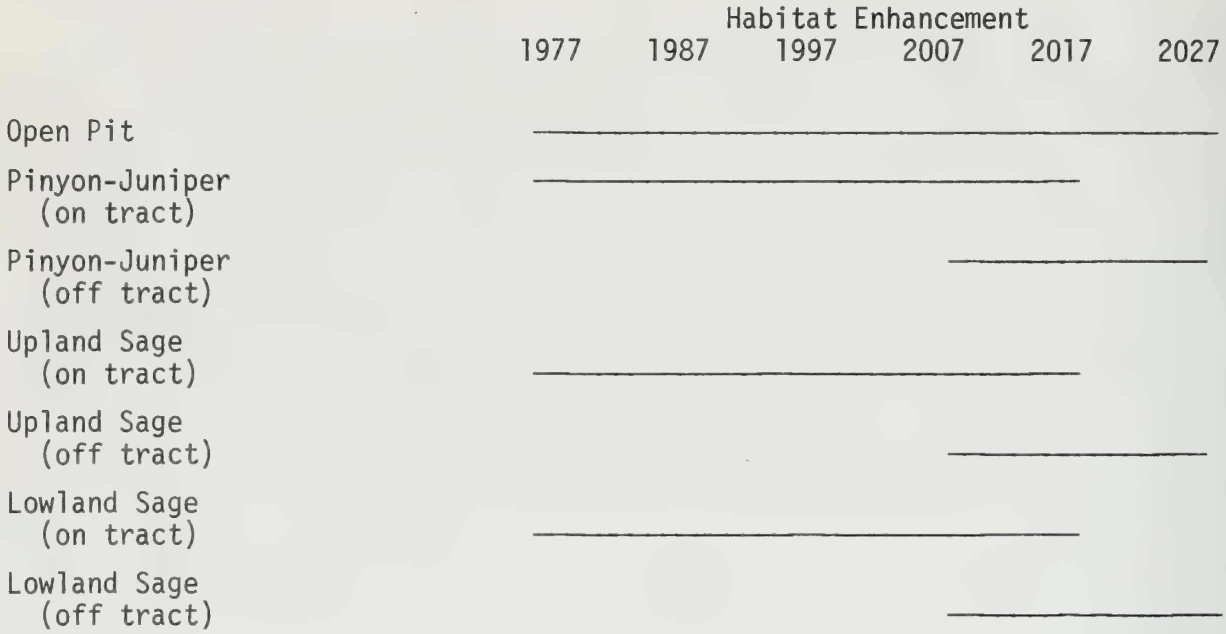
This Wildlife Management Plan must be viewed as a dynamic strategy for reducing negative impacts of oil shale development on the wildlife of the Tract C-a area. As the prototype oil shale development proceeds, the plan will be evaluated and modified if required. Any such modification will of course require notification and approval by the AOSS and appropriate state and federal agencies.

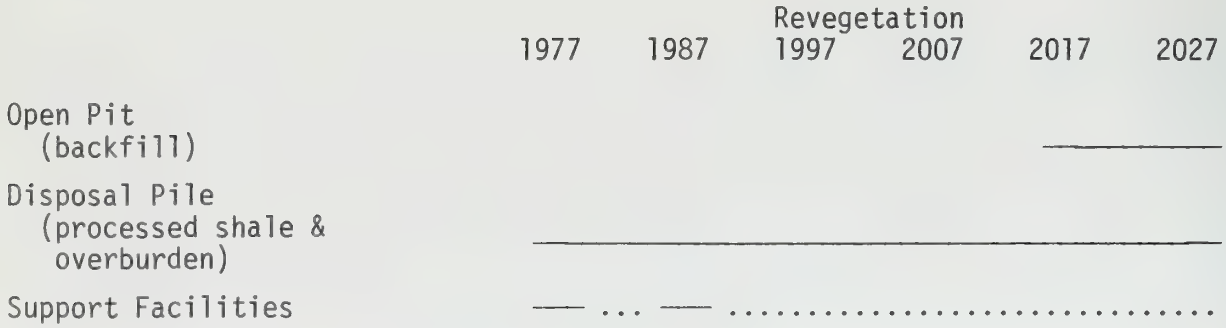
The first five chapters of this plan are presented to familiarize the reader with the plan objectives; the physical setting, wildlife inventory, and present human utilization of wildlife resources within the plan area; and impacts to wildlife resources due to oil shale operations (Sections 3 & 10). The remaining chapters present the means by which RBOSP will mitigate oil shale development and related impacts to wildlife resources; to enhance, replace, and restore lost or altered habitat; to monitor effects of oil shale development impacts and the effects of this wildlife management attempts to alleviate these impacts; and present quality assurance, contingency, and revision plans in order to evaluate, update, and revise this plan as the need arises.

11.1 PURPOSES AND OBJECTIVES

In January 1974, the United States Department of the Interior issued a lease to federally owned oil shale land, Tract C-a. The Oil Shale Lease, Section 4, Environmental Stipulations requires that "the Lessee submit . . . a detailed fish and wildlife management plan which shall include the steps which the Lessee shall take to: 1) avoid or, where avoidance is impraticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event that it is unavoidably destroyed or damaged; 3) provide alternate habitats; and 4) provide controlled access to the public for the enjoyment of the wildlife resources on such lands as may be mutually agreed upon. The plan shall include, but not be limited to, detailed information on activities, time schedules, performance standards, proposed accomplishments, and ways and means of avoiding or minimizing environmental impacts on fish and wildlife."

The following RBOSP time schedule for enhancing and reclaiming habitat on Tract C-a and its environs is based on the best available information. Obviously, as new technology becomes available, these time schedules may change. However, the Area Oil Shale Supervisor will be notified and consulted prior to the change.


Habitat Enhancement


Revegetation

This Wildlife Management Plan will protect wildlife values to the fullest extent feasible. In doing so, two key stipulations of the prototype oil shale leasing program will be fulfilled. These are: 1) protecting the environmental integrity of the oil shale areas; and 2) learning the environmental costs of oil shale development (Wildlife and Grazing Subcommittee, Oil Shale Environmental Advisory Panel, 1974).

It is important to reiterate that all activities described herein will be done within the legal limits of RBOSP authority and jurisdiction. Nonetheless, RBOSP recognizes that the effects of Tract C-a development will extend beyond tract boundaries and that to some degree the existence of such legal constraints may limit the effectiveness of the management plan described herein. For example, the use of deer habitat enhancement areas by off-road vehicles, such as snow machines, could render such enhancement completely ineffective. Yet the lease apparently prohibits the lessee from imposing the kind of regulations needed to control such activities. In general, this wildlife management plan will achieve maximum effectiveness only if it is applied beyond the present limits of RBOSP authority, by the appropriate state and federal agencies. Wildlife management concerns outside of the leased area are more correctly under the jurisdiction of agencies such as the Colorado Division of Wildlife and Bureau of Land Management. Rio Blanco Oil Shale Project will cooperate wherever possible with these agencies in fulfilling the objectives of their preliminary Habitat Management Plan for the Piceance Basin.

This Plan will, as much as possible, address the ecosystem as a whole in an attempt to approach problem solutions in a unified, systematic effort. However, primary emphasis must necessarily be on those species of economic importance, endangered or threatened status, ecological importance, rarity, or high aesthetic value. These "important" species will be considered individually whereas other ecosystem components will be treated as groups.

11.2 PHYSICAL SETTING

Tract C-a is located in western Colorado's Rio Blanco County in the Piceance

Creek Basin. This basin is underlain by the more resistant Green River Formation which contains layers of oil shale beds up to 1,067 m (3,500 ft) thick at variable depths (Baker and McKean, 1971). The terrain in the Tract C-a area varies from abrupt cliffs at elevations of 2,644 m (8,675 ft) on Cathedral Bluffs near the headwaters of Spruce Gulch, through upland parks, broad ridges and deeply cut valleys as the land slopes generally northeastward, to open valleys and low to moderately high rounded hills near the confluence of Duck Creek and Yellow Creek at an elevation of 1,890 m (6,200 ft).

Principal drainageways in the study area include Yellow Creek and its tributaries, Duck Creek, Corral Gulch, and Stake Springs Draw. Yellow Creek flows into the White River north of the tract.

The soils of the study area are part of the plateau land type within the Piceance Basin. These soils are derived from the Uinta formation and Parachute Creek member sandstones, shales, and marls. The soils are primarily formed in place except for the alluvial deposits found in most of the drainages. The plateau soils are generally shallow, sandy loams that range in depth from almost zero on rock outcrops to more than 61 cm (24 in) under dense aspen stands (Thorne Ecological Institute, 1973).

The climate of the area is classified as arid steppe and is characterized by abundant sunshine during all seasons, relatively low precipitation, warm summer temperatures, and low relative humidity (Marlatt, 1973). Annual precipitation in the Piceance Basin ranges from 27.9 cm (11 in) in the northwest corner to 63.5 cm (25 in) on the Roan Plateau. The major portion of the Piceance Basin received 35.6 to 38.1 cm (14 to 15 in) of precipitation, with about equal monthly distribution; evaporation rates are high (Baker and McKean, 1971; Terwilliger, 1973).

A limited variety of aquatic habitats occurs on or near Tract C-a. These habitats include small springs and seepage areas, small spring-brooks and small marshy ponds. The only true river habitat in the study area occurs at the confluence of Yellow Creek and the White River.

11.3 WILDLIFE INVENTORY AND BASELINE RESULTS

Comprehensive, two-year terrestrial and aquatic studies were initiated during October 1974 in order to assess and document the pre-development biological inventory and baseline conditions of the Tract C-a area. A presentation of methodologies, results, discussion, and ecological interrelationships is found in Section 3, Chapter 7 and 8 for terrestrial and aquatic ecology, respectively. A comprehensive discussion of methodologies, results, and discussion can be found in the Annual Report or through previous progress reports, both on file with AOSO. A cursory description of the existing biological environment follows.

A. Terrestrial

1. Vegetation - The majority of the Tract C-a study area is occupied by pinyon-juniper and sagebrush vegetation types. Elevational ranges of these two types overlap, with sagebrush occupying the valleys, mesas or gentle slopes with fine, deep soils and pinyon-juniper occupying ridges and steep or rough slopes having coarse, rocky or shallow soils. Competitive interactions between species increase on soil types and slopes that intergrade. The mixed brush vegetation type prevails on north-facing slopes where winter snow accumulates.

At the lower elevations of the study area, black greasewood becomes more abundant within the sagebrush type on saline alluvial soils. Shadscale occurs within this type as well as on alkaline south-facing slopes along major drainageways.

The higher elevations of the study area support the mixed brush type, characterized by the tall-shrub life form of Utah serviceberry, Gambel oak and mountain mahogany. This type occupies the wetter slopes, too cool for pinyon-juniper but still too dry for aspen (West, et al. 1975). Aspen and Douglas-fir types occur on the steep, generally north-facing slopes near Cathedral Bluffs, with aspen usually occupying a position of slightly lower elevation than Douglas-fir. Ridgetops approaching Cathedral Bluffs support sagebrush which intergrades with the "bald" vegetation type characterized by low, drought-resistant grass and forb species in dry, wind-exposed areas.

Riparian vegetation types are rare and occur in association with small springs in open, alluvial bottomlands. Most of these, like Stake Springs, have been converted to pasturelands which are occupied by common pasture weeds. Other riparian vegetation types occur as a result of hillside springs and seeps along steep draws. Cottonwood Spring is an example which is not heavily grazed and contains a number of plant species unusual for the Piceance Basin due to the paucity of riparian areas within the basin. A third type is found along drainageways of intermittent streams. These generally contain species characteristic of the bottomland sagebrush association.

Browse conditions on the study area were generally classified as "good"; however, a downward trend, or a decrease in condition was noted from the one year of baseline data. Further studies should allow more definitive conclusions. Mule deer use the area primarily as transitional range except in mild winters.

2. Small Mammals - Small mammals depend upon vegetation for food, shelter, and in some cases, their only supply of water. Vegetation distribution is the most important factor controlling the distribution and abundance of small mammal populations in the area.

Generally, vegetation types with the highest shrub cover (greasewood/sagebrush, rabbitbrush, and mixed brush) exhibit the greatest abundances of small mammals. The least chipmunk and deer mouse are the two most abundant species in these and many other vegetation types; they comprised over 75% of all small mammals captured in the study area thus far.

At higher elevations (above 8,000 ft) fewer species of small mammals and lower abundances were observed, presumably because of the harsher environment. Two species, the red-backed vole and the red squirrel, are known to be limited to the aspen and Douglas-fir stands like those found on Cathedral Bluffs.

The greatest small mammal diversity occurs within the pinyon-juniper vegetation type. This is probably a result of the greater habitat heterogeneity. Two species, the piñon mouse and Colorado chipmunk, are found only in this type, and the bushy-tailed woodrat and golden-mantled ground squirrel exhibit an affinity for pinyon-juniper habitat.

Other small mammal species comprising only a small proportion of total abundance are the thirteen-lined ground squirrel, long-tailed vole, montane vole, and sagebrush vole. The northern pocket gopher and porcupine are also residents of the Tract C-a area as are three lagomorph species, Nuttall's cottontail, the black-tailed jackrabbit, and the white-tailed jackrabbit.

Among the insectivores, the masked shrew and Merriam's shrew (a first record for the Piceance Basin) have been identified to date (R. Finley, United States Fish and Wildlife Service, 1975, personal communication). Five bat species, the hoary bat, big brown bat, and three myotis species have also been found in the study area.

3. Big Game - Big game species occurring in the study area are mule deer and elk. Mule deer are the most important of the two in terms of biomass, ecological interrelationships and recreational use. Relatively few elk are located in the study area and they have not been observed within the boundaries of Tract C-a during the first year of study.

Mule deer use the Tract C-a area mainly as transitional and upper winter range. They begin an influx into the area in October during their migration from higher elevations west and south of Tract C-a to winter range north and east of the tract. This movement is a gradual drift of the animals, probably in response to temperature declines and increased snow depth in their higher-elevation summer range and so movements may vary from year to year. Mule deer may use Tract C-a throughout the winter but as snow levels increase, the largest concentrations of deer are located in the pinyon-juniper and sagebrush vegetation types northeast of the tract. During late April and early May, the largest herds of mule deer characteristically occur in the meadows and bottomlands east of the tract. Movement back to the summer range takes place over an extended period. The deer meander through the area and gradually drift to the higher elevations as individuals and small groups. By late May, most of the deer in the study area occur at higher elevations west of Tract C-a.

A large amount of recreational activity is provided by these mule deer as their initial movement into the area usually coincides with the fall hunting season. This aspect of recreational use is disucssed more fully in 11.4, HUMAN UTILIZATION OF WILDLIFE RESOURCES and Section 3 TERRESTRIAL BASELINE.

4. Mammalian Predators - The coyote, the long-tailed weasel, and the short-tailed weasel are the most abundant mammalian predators in the area. Coyote populations seem to be about average for the region based on a comparison of federally obtained data from lines within areas of similar habitat and physiographic characteristics (USDI 1973a, 1974). Other mammalian predators documented in the study area are the bobcat and the badger. Although the mountain lion, black bear and ringtail have not been observed in the study area, they do exist in the region and may occasionally occur in the Tract C-a area (Baker and McKean, 1971).

5. Avifauna - During baseline studies, 129 avian species representing 48 families occurred in the study area. Exclusive of the raptors, waterfowl and game birds, the following species are the common year-round residents: common flicker, horned lark, Steller's jay, scrub jay, pinyon jay, black-billed magpie, common raven, Clark's nutcracker, black-capped chickadee, mountain chickadee, plain titmouse, red-breasted nuthatch, and gray-headed junco. The relatively rare riparian habitats support the greatest bird density and diversity on an annual basis, while sagebrush and rabbitbrush support the lowest numbers of species and individuals.

Avian composition of the area varies seasonally in regard to abundances, diversity, and local distributions. During summer, the largest number of birds and the greatest species diversity are encountered in a variety of vegetation types. Of the 96 species recorded in June, the most common summer residents migrating into the area were the mountain bluebird, green-tailed towhee, chipping sparrow, Brewer's sparrow, and vesper sparrow. A sparseness of birds (low diversity and abundance) is exhibited in midwinter. Among the 23 species recorded in a February census were the tree sparrow and northern shrike, both migratory species from more northerly areas. In spring and fall a composite of winter and summer populations is formed. Many areas may show the uneven pattern of distribution typical of winter, while other areas may host many birds of a considerable variety of species.

Three species of game birds occur locally. In the southwest portions of the study area, a substantial population of sage grouse exists on a year-round basis within upland sagebrush and mixed brush vegetation types. Sage grouse also occur on 84 Mesa. A relatively large population of blue grouse inhabits mixed brush and aspen/mixed brush ecotonal areas during the breeding seasons and dense stands of Douglas-fir and aspen in late fall and winter. The mourning dove is the most widely distributed gamebird in the study area during breeding and migration periods. It resides in a variety of habitats, but it most often frequents pinyon-juniper and greasewood/sagebrush vegetation types.

In the Tract C-a vicinity, a few surface ponds and intermittent streams create isolated islands of habitat for waterfowl and shorebirds. Fourteen species have been recorded using the area; primarily they were spring and fall migrants. Of these, the mallard, green-winged teal, blue-winged teal, killdeer, and common snipe were the most common.

Fourteen diurnal and four nocturnal raptors are known to use the Tract C-a area. The red-tailed hawk was frequently observed during all times of the year except late winter. The rough-legged hawk, a species which breeds in arctic tundra, was the most common wintering raptor. Golden eagles occurred throughout the year with the largest number observed during winter. The march hawk and American kestrel were common nesters during summer, but only a few individuals were recorded during the winter. The common raven was the most prevalent raptor-like species in all vegetation types. Other diurnal raptors included the turkey vulture, goshawk, sharp-shinned hawk, Cooper's hawk, Swainson's hawk, bald eagle, prairie falcon, merlin, and peregrine falcon. Nocturnal species included the great horned owl (most common), pygmy owl, short-eared owl, and screech owl. Thirty-one active raptor nest sites were located in the study area.

6. Reptiles and Amphibians - Five reptile species are known to occur in the study area, of which the sagebrush lizard is by far the most abundant. The others are the eastern fence lizard, tree lizard, short-horned lizard (horned toad), and western terrestrial garter snake. Greatest abundances of lizards were observed in the pinyon-juniper vegetation type where there is adequate open ground for sunning, as well as bushes, deadfalls, and occasionally rocky outcrops providing refuge.

Three amphibian species, the chorus frog, Great Basin spadefoot, and tiger salamander were documented as occurring in the study area at two breeding ponds. The area has very few habitats suitable to breeding populations of amphibians, and abundance and species diversity is low where they do occur.

7. Invertebrates - Invertebrate numerical abundance over the summer was greatest in the greasewood/sagebrush habitat where the active flying insects were very abundant relative to those in other vegetation types. They account for much of the difference in invertebrate numerical abundance between this and the other vegetation types sampled. The sagebrush type contributed the second largest overall invertebrate numbers; however, ground dwellers were the most commonly encountered group in this vegetation type. The majority of invertebrates captured on the ground or in the litter were springtails (Collembola), mites (Acari), and ants (Formicidae).

The mixed brush vegetation type also contained relatively large numbers of invertebrates, occurring primarily in the herbaceous stratum. In the pinyon-juniper vegetation type, ground dwelling and actively flying invertebrates were relatively abundant; however, invertebrate numerical abundance from the tree, shrub, and herbaceous strata relative to that of other vegetation types was low.

Of the shrub species sampled, shadscale had the lowest number and variety of associated herbivorous invertebrates. By contrast, the greatest number and variety of herbivorous invertebrates found on sampled shrub species were taken from rabbitbrush and sagebrush in the greasewood/sagebrush vegetation type.

Seasonal trends from sampling efforts in all habitats indicate that peaks in population numbers and variety of species groups occurred in July. The one exception was the active flying insect group which was at its largest numerical abundance in June.

Major orders of ground dwelling invertebrates in all vegetation types throughout the season were springtails (Collembola) and mites (Acari). Of the active flying insects, the numerically dominant taxa found in all vegetation types sampled were two fly families, non-biting midges (Chironomidae) and anthomyiid flies (Anthomyiidae). Each shrub, tree, and herbaceous species sampled has a complement of herbivore species, primarily from the order Homoptera. Ants (Formicidae) were the numerically dominant family found in all strata when all the vegetation types sampled are considered.

8 Wild Horses - Horses use portions of the study area throughout the year and are most frequently observed west of Tract C-a, although herds also occur on both 84 Mesa and Wolf Ridge. The largest herd of horses in the study area is frequently seen on the southwestern edge of Wolf Ridge. Horses have been noted several times immediately adjacent to the tract but have seldom been recorded within the tract boundaries. This distributional pattern is probably associated with human disturbance factors in conjunction with pre-development activities. Fences may also restrict movements over certain portions of the study area.

9. Domestic Livestock - Cattle distribution and dispersal in the area are dictated mainly by herding and climate. Cattle are moved to higher elevational ranges in the spring as the snowpack recedes and vegetation becomes green. In the fall, inclement weather conditions force the cattle to return to lower-elevation rangelands.

10. Threatened and Endangered Species - Federal and State Wildlife Agencies and the Smithsonian Institution have compiled lists of plant and animal species which are "threatened", "rare", or "endangered". In determining the status of a species, the entire range of that species is considered. By federal standards, an "endangered" species is in danger of extinction throughout all, or a significant portion, of its range; a "threatened" species is likely to become endangered within the foreseeable future throughout all, or a significant portion of its range; and a "rare" species exists as a small population within its range (United States Department of the Interior, 1973b).

Habitats of rare plants are often associated with young or unstable geologic conditions such as talus slopes, mountain tops, rock cliffs, or shale barrens (Smithsonian Institution, 1975). One endangered plant species, a milkvetch, *Astragalus lutosus*, was found growing on shale outcroppings northwest of Tract C-a. The rare milkvetch is known only to occur on dry, calcareous shales at lower elevations in the drainages of the White River, Rio Blanco County, Colorado, and adjacent areas of Utah.

The peregrine falcon (*Falco peregrinus anatum*) is considered an endangered species by the United States Department of the Interior (1975). It has been observed four times in the Tract C-a study area since October 1974. Two of the observations were within the tract boundaries. It is impossible to determine how many individuals (from one to four) the four sightings represent because of the high mobility of this raptor. It is unlikely that peregrine falcons nest in the study area due to the lack of large cliff faces and the paucity of water (G. Craig, Chief Raptor Biologist, Colorado Division of Wildlife, personal communication, 1975).

The Colorado nesting population of the greater sandhill crane (*Grus canadensis tabida*) is considered endangered by the Colorado Wildlife Commission (1973). Approximately 30 greater sandhill cranes were recorded in the study area. Based on observations made during spring and fall surveys, 84 Mesa and its environs may serve as a staging and foraging area for cranes during their spring and fall migrations. Extensive surveys were conducted to determine if these cranes were nesting along the White River but none were sighted.

B. Aquatic - Periphyton is the major source of autochthonous primary production in waters of the study area. Periphyton standing crops were usually greatest in the White River and lowest in the waters of the headwater and tract areas. In the alkaline spring-brook habitats of the headwater and tract areas, diatoms comprised the dominant algal group in the periphyton. The most abundant taxa included *Achnanthes minutissima* and *Navicula cryptocephala*. Shannon diversity indices for periphyton were lowest in the headwater and tract regions, suggesting that the periphyton communities in these regions were less complex than those in the most permanent streams of the region. In Yellow Creek, diatoms generally dominated the periphyton but filamentous algae, including *Chara kieneri* and several blue-green species, were also frequently abundant. Periphyton diversities in Yellow Creek were intermediate between those of the tract and headwater areas (lower diversity) and those of the White River (higher diversity). In the White River, the diatoms were again the dominant taxa in the periphyton. Periphyton standing crops and species diversities were higher in the White River than in any other of the study areas. The most abundant alga in the White River periphyton was the diatom *Epithemia sorex*.

In all study areas, the phytoplankton were usually a secondary source of primary production and in most areas the phytoplankton species composition and abundance indicated that phytoplankton was primarily recruited from the periphyton. Diatoms generally dominated the phytoplankton in all areas. Different phytoplankton species were dominant in each of the three general areas of study (i.e., tract and headwaters, Yellow Creek and the White River), and phytoplankton abundance was generally low in all areas.

The zooplankton fauna in the spring-brook habitats of the headwater and tract areas consisted primarily of species associated with a substrate. The dominant Crustacea in these spring-brooks included the cyclopois *Eucyclops agilis* and the harpacticoid *Bryocamptus hiemalis*. The peak densities and number of species of both rotifers and cladocerans occurred during the summer months. The zooplankton fauna of the marshy pond area (Station 5) on Stake Springs Draw was generally similar to that of Yellow Creek. At the pond (Station 14) on Corral Gulch, the dominant taxa included rotifers and

Crustaceans. At that pond the dominant fauna included *Ceriodaphnia quadrangula*, bdelloids, *Monostyla*, *Lepadella*, *Euchlanis* and other monogononts. The zooplankton fauna of the pond area (Station 19) of lower Yellow Creek differed from other areas of study in that portion of Yellow Creek. The rotifer fauna of Yellow Creek included *Notholca acuminata*, *Notholca squamula*, and *Colurella adriatica*. The most abundant Cladocera of Yellow Creek were typically summer species and included *Pleuroxus aduncus* and *Alona circumfibriata*. The paucity of lakes, ponds, pools, and backwater areas in the White River near the study area accounts for the low abundance of planktonic rotifers and limnetic Crustacea in the White River. The cladocera of the White River included *Alona*, *Pleuroxus* and *Chydorus*, but abundance of these organisms was also low (Figure 9-11-2).

The benthic fauna of the spring-brooks of the headwaters was dominated by Oligochaeta belonging to the Naididae and Enchytraeida and by aquatic insects, particularly the Chironomidae and Simuliidae. The benthic fauna of the spring-brooks of the tract area included taxa with rapid life cycles and taxa which can easily invade new waters. Whereas the densities of certain benthic taxa remained high in the tract region, the number of species and the species diversity and richness were lower than those in the headwaters. The intermittent nature of many of the waters on and near the tract limits the fauna which can exist there and thus limits diversity. As in the headwaters, the aquatic insects and Oligochaeta dominated the benthic fauna of the spring-brooks on and near the tract. In the marshy-pond habitat at Station 5 (headwater area) where sedges, watercress and other vegetation were abundant, the most abundant benthic taxa belonged to the Tubificidae, Chironomidae, Ephemeroptera, Simuliidae, and Oligochaeta. In the single pond habitat (Station 14) of the tract area, the benthic community included Ephemeroptera, Corixidae, Dytiscidae, Chironomidae, Ceratopogonidae, Anthomyiidae, and Oligochaeta. In Yellow Creek, the diversity of the benthic fauna was limited by the harsh chemical conditions which occurred there. Those species which tolerate the harsh conditions, particularly the Simuliidae and Chironomidae, occurred in great abundance. The dominant benthic organisms in Yellow Creek were aquatic insects and Oligochaeta. In the pond area (Station 19) of Yellow Creek, the number of species and the

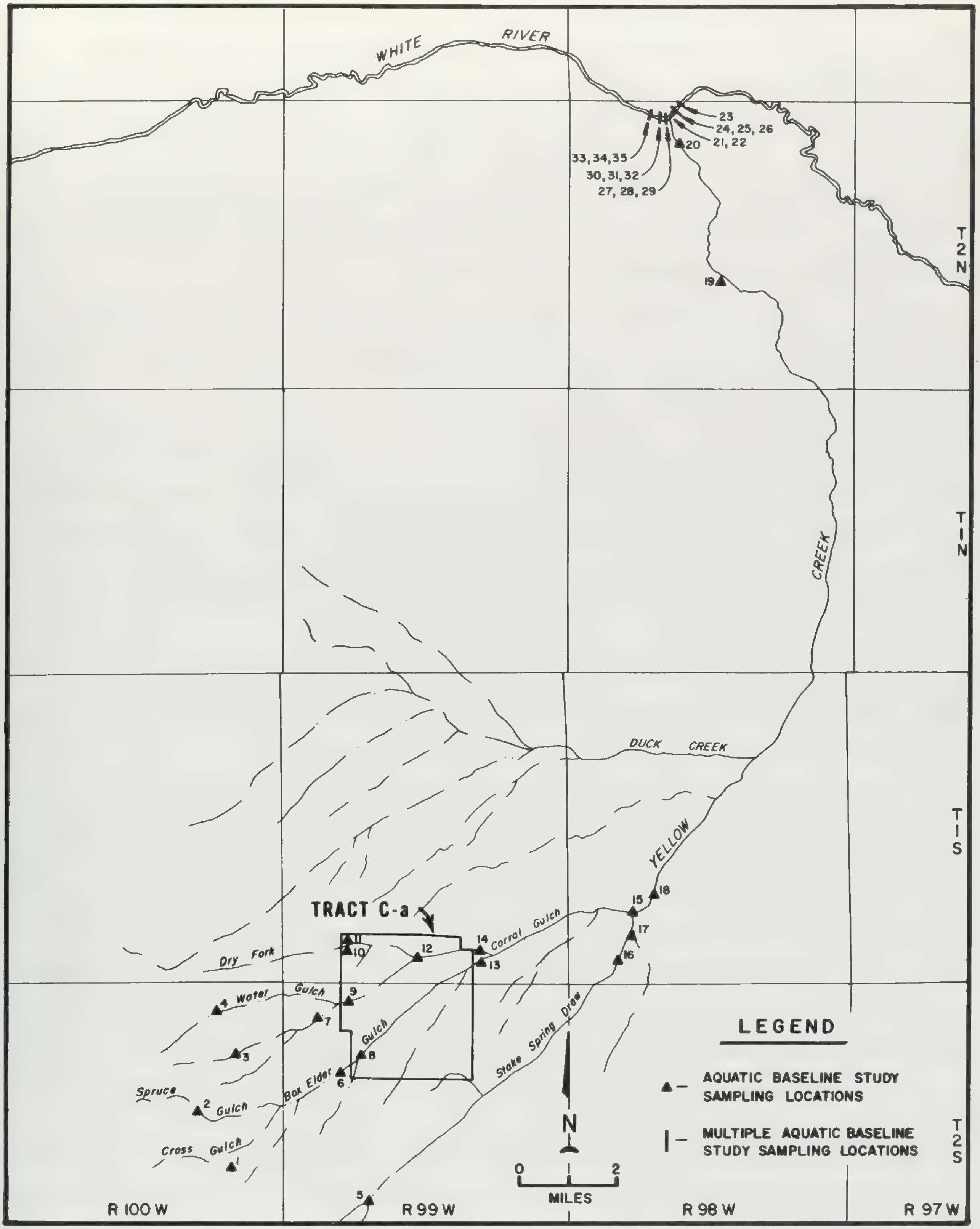


Figure 9-11-2

RBOSP AQUATIC SAMPLING LOCATIONS

species richness were generally higher than in any other area of the creek. The rubble substrate of the White River provides many interstitial spaces as available habitat for benthic organisms. The benthic diversity in the White River was higher than in any of the other areas studied, but the density of benthic macroinvertebrates was lower than that of Yellow Creek. The most diverse species occurring in the White River were Ephemeroptera, Trichoptera, and Plecoptera; the most abundant benthic macroinvertebrates were the Ephemeroptera, Diptera, and Oligochaeta.

Studies of the fishes of Yellow Creek and the White River indicated that the occurrence of fish in Yellow Creek is restricted by harsh physical and chemical conditions. The most abundant fish species observed in the White River study area were rough and forage species. They included flannelmouth sucker, blue-head sucker, speckled dace, fathead minnow, and mottled sculpin. Trout were rare in the study area, a fact at least partly due to the higher than optimum water temperatures which occur periodically and to the high concentrations of suspended solids which are deleterious to trout eggs.

The fish recorded in the RBOSP study area occurred primarily in the White River. Physical characteristics such as rapid temperature fluctuation and low discharge restricted fish occurrence in Yellow Creek.

The fish community of the White River is dominated by members of the minnow, sucker, and sculpin families (e.g., flannelmouth sucker, bluehead sucker, speckled dace, fathead minnow, and mottled sculpin). With the exception of fathead minnow, they are native species, and all are well adapted to the swift, turbid, "cool water" environment.

Game fish such as trout and mountain white fish are rare in the study area. The reason for this is a combination of factors including periodic elevated summer water temperatures, insufficient shelter, and high silt loads. The latter is probably the most important factor because of the deleterious effect of silt on trout eggs. Those areas of the White River in the study that might otherwise be suitable for trout spawning have deep silt loads. Consequently, no significant fishing occurs in this stretch of the White River. A minimal amount of angling for channel catfish apparently is carried out by a few local residents.

11.4 HUMAN UTILIZATION OF WILDLIFE RESOURCES

Wildlife resources, as defined for this discussion, include the land, water, flora, and fauna in the tract area.

A. Terrestrial - In historic times, Ute Indians originally occupied and used the local resources. As white men settled the area and the Indians were forced to relinquish their holdings, the livestock industry became established and continues to be of primary importance in the region. Federal, state (Division of Wildlife and State school land), and private lands have been combined into three ranching operations within the study area: the Reagle Allotment includes 10,503 ha (25,942 A); the Square S Allotment, 30,685 ha (75,792 A); and the Box Elder Allotment, 12,247 ha (30,250 A). Stocking rates recommended by the Bureau of Land Management are 1,266 AUMs, 3,330 AUMs, and 1,400 AUMs, respectively, for the three allotments. (AUM is number of animals that a range can support based on their grazing habits.) Feral horses have been observed grazing the same area.

Ranching requirements have changed the biological complexion of the region. Large predators were gradually eliminated or drastically reduced in numbers because they affected the profitability of the livestock industry. Animals such as bears, cougars, and wolves were systematically removed by trapping and bounty hunting. The American bison (buffalo), a native ungulate, was extirpated by uncontrolled hunting before the cattle industry began. Reintroduced in the early 1960's, buffalo proved to be incompatible with livestock interests. The herd of approximately 30 animals could not be contained by conventional fences and consequently were removed in 1973-1974.

A limited amount of vegetation manipulation such as sagebrush eradication by burning and aerial herbicide application has occurred on public lands within the study area. On private lands along streams to the southeast and northeast of Tract C-a, arable lands have been converted to hay fields.

The major recreational use of the area's wildlife resource is big game hunting. Tract C-a is located in Colorado Division of Wildlife's (CDOW) big game management Unit 22. Unit 22 (Piceance Basin) is recognized as one of the principal mule deer hunting areas in Colorado in terms of number of hunters in the field and number of deer harvested. The following table presents harvest statistics for Unit 22 and the State of Colorado for the five-year period, 1970-74.

Table 9-11-1

HARVEST STATISTICS FOR UNIT 22 AND THE STATE OF COLORADO

FOR THE FIVE-YEAR PERIOD, 1970-74[1]

	Number of Mule Deer Harvested[2]		Hunter Pressure Expressed In Hunters per Square Mile	
Year	Game Management Unit 22	State of Colorado	Game Management Unit 22	State of Colorado
1970	4,737	70,254	7.07	1.65
1971	3,046	40,056	5.36	0.91
1972	5,446	66,109	7.27	1.24
1973	2,030	75,451	4.43	1.60
1974	1,982	54,142	[3]	[3]

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[1] Data from Big Game Harvest Statistics published yearly by the Colorado Division of Wildlife 1971, 1972, 1973, 1974, and 1975.

[2] Includes all deer harvested from 1970 and all deer harvested exclusive of archery for 1971-74.

[3] Not listed for 1974.

The harvest has declined in recent years, primarily because of lower mule deer population levels. More non-residents than residents hunt in Unit 22. Limited elk hunting occurs west of Tract C-a as well, and harvest of this species is increasing.

Small game and waterfowl are not as heavily hunted as big game animals. The small game animals harvested in the vicinity of Tract C-a include the cottontail rabbit, mourning dove, sage grouse, and blue grouse. Waterfowl hunters generally hunt Rio Blanco Lake, the White River, and Piceance Creek and its larger tributaries, but seldom hunt near Tract C-a. Most waterfowl harvested are migrants. Predator hunting of coyotes and, to a lesser extent, bobcats, is practiced in the area for sport and fur.

Trapping intensity varies, depending upon the price of furs. Relatively little trapping for a particular species occurs until prices paid for pelts reach a profitable level. Trapping in the tract area is primarily limited to coyotes, bobcats, and occasionally weasels.

Before enactment of the Wild Horse and Burro Act in 1971, some local ranchers and cowboys occasionally captured wild horses. The feral horses that were captured were sold to finance local barbeques and dances. If the constitutionality of the Act is upheld by a Supreme Court decision expected in 1976, these activities could not be renewed.

Other recreational activities such as snowmobiling, jeeping, hiking, hunting for gemstones, minerals and artifacts, scenic viewing from Cathedral Bluffs, observing wildlife like the feral horses, and short trips focused on appreciating the relatively remote and undisturbed area are not as publicized as hunting; nevertheless, these represent additional important human uses of the area's resources. Scientific studies should also be included in this list. The level of resource use for these activities is not as easily quantified as is hunting or livestock grazing since people involved in the activity are not required to have a license or to register their activities.

Residential dwellings are widely separated in this sparsely populated area. Those residences that are present are usually associated with ranching operations and to some extent, hunting. A hunting club used to own several permanent buildings on Tract C-a which were used during the big game season.

B. Aquatic - Because no fishery exists on or near Tract C-a, and because the fishery of the White River is generally limited to rough and forage species below the confluence of Yellow Creek. There is essentially no human utilization of the aquatic biota of the area other than that associated with occasional scientific studies.

11.5 DEVELOPMENT-ASSOCIATED IMPACTS

A. Terrestrial - The terrestrial ecological effects of oil shale development on Tract C-a are discussed in detail according to development phase and referencing supporting literature and baseline data in Section 10, Chapter 5. This section summarizes the primary impacts associated with the major categories of activity of the Tract C-a oil shale development. A worst-case situation is assumed to be Phase II for most impact categories. Special deviations from this assumption are pointed out in the text.

Impacts of development will result from:

- Area disturbance
- Processing plant emissions
- Mine dewatering
- Dust
- Noise
- Secondary effects

1. Area Disturbance - Following the impact assessment period of Phase II (December 1987) approximately 850 ha (2,100 A) will have been disturbed by development activities. The greatest reduction will be of sagebrush and pinyon-juniper (42% and 41%, respectively), and mixed brush (13%). Lesser amounts of shadscale, upland meadow, agricultural, riparian, and rabbitbrush vegetation will also be eliminated.

The removal of this vegetation may result in habitat reduction for the associated mammalian, avian, and invertebrate herbivores with a concomitant reduction in food supplies for local predator populations. Reduction of small mammal carrying capacity will be on the order of 3-5 individuals per ha (1-2/A) removed for the most abundant species (least chipmunk and deer mouse) (DDP Section 3, Chapter 7). Habitat supporting one cottontail will potentially be eliminated for every 1.6 ha (3.5 A) disturbed.

The greatest impact of area disturbance to avifauna is the removal of nesting habitat. This reduction can be counted as a reduction in the local breeding population of birds. Displaced species may or may not be able to establish themselves depending upon carrying capacity of surrounding habitat. Elimination of locally unique or restricted vegetation types, especially the riparian type, has a disproportionate impact since this reduction in vegetation type represents a significant proportion of that available in the study area. This will result in a decrease in study area populations of waterfowl, shorebirds, and other species dependent on the special habitat associated with these surface-water resources.

Ungulates will avoid using much of the disturbed area. This may place an added burden on rangelands outside of the developed area where competition between and among horses, cattle, deer, and elk for food may cause deterioration of range and browse condition and result in a local decline in the condition and abundance of these ungulate species (Koehler and Potter, 1974). The presence of the development may also interfere with the movement of local deer herds between winter and summer ranges.

The recreational and economic importance of deer in the Piceance Basin makes potential range deterioration a serious concern. McKean and Bartmann (1971) suggest that mule deer winter range may be able to comply with deer-use rates up to 2.0 acres per deer-month. Under certain conditions crowding, even with adequate food supplies, may become detrimental to deer (Dasmann, 1971); and in cases where food supplies are inadequate, crowding can be detrimental to the range as well.

Elk are not abundant locally and their populations may suffer in the future from increased competition with deer and horses for food resources. Increased human access to and use of the Cathedral Bluffs area might further restrict acceptable elk range due to avoidance reactions. Ward (1973), in a study in Wyoming, concluded that elk prefer to stay about 277 m (300 yds) from moving vehicles on roads and about 0.8 km (1/2 mi) away from people.

Horses present a special set of difficulties for impact assessment. The Wild Free-Roaming Horses and Burros Act of 1971 provided total protection to United States wild horse and burro herds. The total protection afforded by the Act has permitted herds around the country and on the study area to increase in numbers. At the present time, the horse population in the study area numbers about 150 animals. Since the initiation of pre-development activities, some of the freal horse herds have moved out of the tract towards Cathedral Bluffs. These herds are possibly supported by a more limited range than before development and are dependent on scattered springs (notably Maverick Spring in Corral Gulch) for water. Baseline range investigations have been started by the BLM in the vicinity of Tract C-a for input for consideration of the area as a wild horse management area.

The legal status of United States wild horse herds was complicated by a recent federal court action in New Mexico ruling the Act unconstitutional. This decision is presently under appeal to the United States Supreme Court (Reavley, 1974). If the Act is declared unconstitutional, the responsibility for management of the horse herds will probably revert to the individual states.

An additional possible approach proposed at the 1974 meeting of the National Wild Horse and Burro Advisory Board was to establish 10-20 designated "intensive management units" (wild horse refuges) and allow other horse populations to revert to state control. Because of competition by horses with cattle for range resources, cattle ranching interests are pressuring state and federal management authorities for adoption of such a plan which might allow removal of horse populations from areas outside of designated refuges. The oil shale developments planned for the Piceance Basin make the area an unlikely prospect for creation of a possible refuge.

Invertebrate population structure may be changed in the disturbed areas. Most of the flying insects will escape the disturbance, possibly temporarily elevating the degree of insect herbivory in adjacent areas. Bees will probably not escape since queens would be destroyed with the nests.

Lizard populations will be reduced with their invertebrate prey. Avian and mammalian predators will have their available hunting territory reduced by the amount of the disturbed area. Since food supply may be a limiting factor for predator populations, the removal of the development area may result in a reduction of predator numbers in the study area proportionate to decreases in their prey populations. Because predators are frequently very wide-ranging and the area disturbed by development is small relative to the study area, any resultant predator population reduction will be minimal.

At present, no unique species or critical habitats are known to be included in the area of disturbance. Riparian habitat is uncommon locally and the reduction of even a small amount will probably result in a sharp drop in species which depend on it for survival and for which there is no alternate habitat in the vicinity. Protected species, such as the milkvetch _Astragalus lutosus_ or the peregrine falcon (nesting) have not been located in the area of disturbance (Section 3, Chapter 7) so no impact is expected on any species having special legal status. Greater sandhill cranes have been seen in the area (84 Mesa), but their legal status in Colorado is dependent on their nesting in the state. No nesting cranes have been located to date locally.

2. _Processing Plant Emissions_ - Gaseous and particulate emissions, if present in high enough concentrations, can have a profound negative impact on local flora and fauna. Stack gases can be toxic causing chlorosis or necrosis to plants and physiological disruption in vertebrates (Sakakura, 1973; Lewis, Glass, and Lefohn, 1975). Many species of invertebrates, including bees, an important pollinator group, are also sensitive to various fumigants. In any case, severe plant damage or vegetation type changes, if they occur, would effect concomitant changes in the associated fauna due to reduction in total available food.

Based on current studies, fugitive salts (5 grams/m^2/year at 400 meters from the point source) may not be of major importance to the overall biological community.

In addition, the majority of the salt deposition will occur within the plant perimeter where little vegetation or animal life will occur. Products, by-products and wastes of oil shale processing will be carefully transported and disposed.

3. Mine Dewatering - Recent dewatering analysis studies suggest that the water level in portions of both Yellow and Piceance creek basins will be affected by Tract C-a mine dewatering except for those springs supplied by perched water tables.

Mine dewatering may cause some lowering of major elevation springs and their associated habitats may be eliminated. This includes important riparian habitat in Stake Springs Draw which supports abundant and diverse wildlife (Section 3, Chapter 7). RBOSP intends to augment water supplies not only as legally required but as mitigation for habitat impact.

If lower surface water flows are reduced, those species such as deer and horses which might move to springs at higher elevations to the west of Tract C-a may be subject to increased competitory stresses due to increased local population densities in the vegetation types surrounding these water sources.

4. Dust - Ambient levels of dust in the air in the Piceance Basin sometimes approach or exceed government standards (Fosdick and Legatski, 1975). Thus, any contribution to this dust load by development may result in exceeding those standards.

Dust may impact local flora and fauna in several ways. In severe cases, dust may cause leaf surfaces to be coated and stomates clogged sufficiently to interfere with photosynthesis. Vertebrate lung tissue may accumulate minute dust particles and fine dust may interfere with insect respiration. Effects of dust are not expected to be serious except, possible, immediately adjacent to long-term dust sources and dust levels have been minimized as identified in Section 9, Chapter 5.

Construction activities have the greatest initial potential for dust production and require constant control attention during the dry months. After construction is completed and the development is fully operational, the major dust production potential will be from processed shale and overburden piles, road dust, mining dust, and conveyor dust.

5. Noise - Noise production can be substantial for some operations. Haul trucks, conveyors, crushers, and other mechanical equipment may be point sources of noise levels up to 90-120 dBA. These levels exceed the federal regulation levels for 8-hr exposure to humans. It might, therefore, be expected that resident animals very near these sources of noise would suffer some physiological or phychological effects. Noise will result in diminished population densities of moderately sensitive species of mammals and birds immediately adjacent to the noise source. This effect will rapidly attenuate as distance from the noise source increases.

Because most of these noise sources are surrounded by or enclosed within larger areas of physical disturbance (e.g., mine pit, plant site), the greatest exposure of wildlife to noise is expected along haul roads. Constant heavy truck traffic will contribute to a narrow roadside zone of reduced mammal and bird abundances.

6. Secondary Effects - The increased numbers of people visiting, using, and working in the Tract C-a area is considered a secondary effect of oil shale development. Their presence will have concomitant indirect effects not specifically related to development activities. For example, increased traffic on area roads will increase vehicle-animal collisions ("road kills"). Introducing greater numbers of humans to relatively remote areas might be expected to greatly increase legal and illegal hunting pressure on local game populations. Increased (unrestricted) off-road vehicle use will result in range and slope deterioration.

B. Aquatic - During the development and operation of the Rio Blanco Oil Shale Project, aquatic habitats on and near Tract C-a will be subjected to a variety of impacts. During construction of facilities, increased turbidity and siltation resulting from erosion and fugitive dust will occur in many of the aquatic habitats on the tract. The major possible effect on aquatic habitats, including those on and near the tract as well as Yellow Creek, may be the decrease flow of springs and seeps associated with mine dewatering. Runoff and leachate from processed shale piles flow into nearby holding ponds where it is impounded and used in operations.

The effects of increased turbidity and siltation will be localized and transient in nature since many of the habitats to be affected already experience periods of high turbidity and suspended solids concentrations. The effect of mine dewatering may be to reduce those permanent aquatic habitats whose source is the deep oil shale aquifer.

11.6 SPECIFIC IMPACT-RELATED MITIGATION

Implementation of this Wildlife Management Plan will be directed by a supervisor of Rio Blanco Oil Shale Project. This person will serve a quality assurance function, overseeing specific impact-related mitigation.

A. Terrestrial - The following is a discussion of specific impact-related mitigation.

- Monitoring program
- Mitigating land disturbance
- Mitigating processing plant emissions
- Mitigating mine dewatering
- Mitigating dust
- Mitigating noise
- Secondary effects
- Feral horse control
- Fencing

1. Monitoring Program - Mitigative procedures will be observed to assure that they meet the objectives of the Fish and Wildlife Management Plan. The monitoring program will allow an assessment of the effectiveness of mitigative procedures, the detection of unanticipated impact, and the formulation and

application of new mitigative procedures where needed.

2. Area Disturbance - The impacts of area disturbance can be mitigated by initially minimizing the total area disturbed and by revegetating areas that are disturbed. The first objective, that of minimizing total initial disturbance, will be accomplished by an engineering design resulting in closest feasible placement of separate facilities and contract specification of disturbance boundaries during construction activities. Mining related area disturbance will be limited to those areas currently under production. This will allow a maximum amount of habitat and vegetation for the longest period of time. These restrictions and precautions placed on the movement of construction equipment will help minimize area disturbance.

Revegetation will be undertaken in peripheral areas disturbed during construction along pipelines, on disposal piles, and backfill areas. The establishment of a permanent, self-propagating ground cover on disposal piles and backfill areas are essential to long-term surface stabilization and to eventual habitat restoration. Chapter 8 describes known procedures and a development program for determining optimum techniques of revegetation in the local area.

3. Processing Plant Emissions and Effluents - Gaseous and particulate emissions impacts and salt drift impacts can only be mitigated to the extent that the quantities of these emissions can be minimized. Systems designed to reduce emissions are described in Chapter 5. The emissions must be maintained below applicable state and federally regulated limits.

Toxic liquid spills will be contained by completely enclosing the potentially affected areas with a zero-discharge containment system. Collection of runoff with elevated levels of toxic substances increases the severity of damage should this control system fail. Long-term control of runoff depends on the covering of processed shale with overburden and its successful revegetation.

4. Mine Dewatering - If mine dewatering causes large fluctuation in water levels of the major springs, then RBOSP would anticipate augmentation programs to mitigate specific significant adverse impacts. Gallinacious guzzlers will

be established in areas where needed if the drying of minor springs adversely affects wildlife populations.

5. Dust - Planned dust emission mitigative procedures are described in detail in Chapter 5. These include watering down the dust on roads, disposal piles, and haul truck loads. Sophisticated mechanical controls on the enclosed crusher and conveyor systems and, in the longer term, revegetation of all areas feasible, especially disposal pile surfaces, will provide adequate mitigation. In certain cases, mechanical surface stabilization or use of chemical dust stabilizers may be needed to provide more dust control in addition to water sprinkling.

6. Noise - As described in Chapter 4, noise production will be largely controlled by standard vehicle exhaust control devices and by enclosing noise-producing facilities (usually for dust control). Maintenance of this equipment will insure the lowest feasible levels of noise.

7. Secondary Effects - These impacts can be mitigated by restricting activity areas and surface travel routes. Specific mitigative measures are described in 11.8 HUMAN DISTURBANCE CONTROL.

A basin-wide approach, which provides for controlling the pace of development, monitoring the basin-wide impacts, individual and collective mitigative measures, and enhancement of remaining undisturbed habitat has already been instituted through the efforts of the Colorado Division of Wildlife and the Bureau of Land Management. Deterioration of the environment in the Piceance Basin, and resultant losses of ecologically or economically important species due to cumulative effects upon air, water sheds, and surface areas basin wide, will be some of the topics considered in the formulation of this plan.

8. Regulation of Feral Horse Use - Forage is a chief factor affecting mule deer distribution on winter and transitional ranges (Julander, 1966). Recommendations regarding feral horse management cannot be made until a jurisdictional dispute is resolved by the United States Supreme Court. A decision is expected during 1976. Feral horse management should assure that

important mule deer browse species are not over-used by feral horses in the study area. Any improvements in available forage would benefit the deer population.

9. Fencing - Should mining activities or support facilities such as haul roads or runoff collection ponds pose a threat to the health or lives of wildlife, then RBOSP will contemplate using either drift fencing or exclosure type fencing to alleviate such problems. The RBOSP supervisor in charge of this plan, after analyzing either potential or existing problem areas, will enact the construction of fencing wherever feasible.

B. Aquatic - Specific procedures designed to mitigate the effects of erosion, fugitive dust, and runoff and leachate from processed shale are presented in Chapter 5, Air Quality Control and Chapter 6, Water Quality Control, and Section 8, Chapter 5, Water Supply.

11.7 WILDLIFE HABITAT ENHANCEMENT AND RESTORATION

A. Terrestrial - The concept of reducing the negative impact of oil shale development on wildlife by increasing the carrying capacity of lands adjacent to those areas to be rendered unproductive is a practical and attractive mitigation measure. The problem of compensating for impacts could conceivable be solved by manipulating the quality and quantity of food, water, and cover. However, many complicating factors affect wildlife response to management practices and even the most intensive management efforts may not have the desired effect of producing and sustaining more animals (Einarsen 1956).

Wildlife species found near Tract C-a have evolved in association with the vegetation of the area. Oil shale development will, to some extent, disrupt that system and the objective of wildlife enhancement measures are to increase productivity and, in doing so, compensate for that disruption. To this end, care will be exercised to insure that habitat manipulations are not counterproductive. Information gained by the implementation of this Plan may be adapted for use in other areas of the basin by appropriate agencies.

Habitat enhancement will be addressed below as a two-stage process. In the early stage of development, habitat enhancement measures will be confined within the tract boundaries, primarily in the southern half of the tract, the area farthest from development activities. The vegetation types amenable to manipulation for increased wildlife productivity (i.e., large acreages of dense pinyon-juniper or upland and lowland sagebrush) are of limited distribution on the tract. Nonetheless, existing acreages of these types should be sufficient to allow mitigation of habitat losses during the early stage of development. During later stages of development, if on-tract procedures are successful, it will be necessary to use the same habitat enhancement procedures for the tract as are applied off tract. During the first stages of development then, the groundwork must be laid in consultation with the appropriate state and federal agencies for extending provisions of the management plan beyond the Tract C-a boundaries. The general areas in which this extension of habitat enhancement would be most effective are outlined in Figure 9-11-1.

A basic assumption of this plan is that such a two-stage process of habitat enhancement can and must be applied if the negative effects of Tract C-a development are to be properly mitigated.

A number of wildlife enhancement techniques have been explored in the literature and considered for for inclusion in this Plan. The following topics will be addressed in detail and conditions for their implementation described:

- Pinyon-juniper modification
- Structural habitat construction
- Water developments
- Habitat restoration

The RBOSP Supervisor will oversee the implementation of wildlife habitat enhancements. This person will also report on the success of the program as part of the review cycle.

1. Pinyon-Juniper Modification - Until recently it has generally been accepted that mule deer populations are limited chiefly by the quality of winter ranges. This concept has changed and wildlife managers have lately

placed increasing emphasis on the importance of summer and transitional ranges (Julander, 1963). Animals entering the winter with maximum energy reserves are most likely to survive this critical period in good condition.

Summer and transitional ranges are also more amenable to habitat manipulations than are winter ranges. They are situated at higher elevations and lie within more favorable precipitation zones. This is not to say that winter range is not critically important or that the maintenance of its productivity is not crucial to the survival of mule deer populations.

Much of the Tract C-a study area is transitional range. The largest proportion lies in intermediate elevational zones which accommodate migrating deer in the fall and spring. Wildlife habitat enhancements in pinyon-juniper and to some extent sagebrush vegetation types are directed at improving this transitional range. Lower portions of this transitional range become winter range during molder winters.

A variety of pinyon-juniper modification strategies were explored in developing specific guidelines to be used near Tract C-a (Terrel and Spillett, 1975; Kundaeli, 1964; Arnold and Schroeder, 1955; Reynolds, 1963). It should be noted here that application on pinyon-juniper modification will be very selective. The following specifications take into account the needs of mule deer, cottontail rabbits, raptors, and to some extent, passerine birds, small mammals, and mammalian predators:

- locate treatment areas in relatively homogeneous pinyon-juniper stands with dense canopy cover, at lower elevations that do not retain much winter snow and are not overly susceptible to erosion (i.e., mesa tope and slight to moderate south-facing slopes)
- locate treatments in areas with browse understory and good potential for increasing browse production
- create a mid-successional vegetation matirx with high species diversity and good spatial heterogeneity
- limit treatments to many relatively small, irregular openings 50-100 m wide
- treatments at any one point in time will be small in relation to total

habitat area
- leave slash and woody debris in treatment areas for use in the construction of brush piles or windrows
- leave islands of habitat containing dead standing trees (snags), or trees containing nest holes or known nesting sites
- retain "leave strips" at least 200 m wide between treatments

Habitat enhancement of dense pinyon-juniper stands will be enacted in two phases. During Phase I, selected stands of pinyon-juniper will be chained within the southeastern section of Tract C-a (Figire 9-11-1). However, as these on-tract habitat enhancement procedures are negated by impacts of expanded mine development during Phase II, enhancement procedures will then be enacted off-tract. Final off-site selection of enhancement areas will be made with the cooperation of BLM, CDOW, and AOSO.

In order to remove selected stands of dense pinyon-juniper vegetation, caterpillar tractors will move through the designated areas with 60 m (200 ft) of heavy anchor chain (41-kg (90-lb) links) dragging between and behind them in a "U" configuration. Depending on the degree of overstory uprooted, as determined by the RBOSP Supervisor, chaining may be performed in opposite directions to maximize kill of trees. Treated plots will be randomly situated (within selected areas) and irregular in shape to obtain a more natural and aesthetically pleasing appearance.

Modifying pinyon-juniper in this fashion is designed to benefit both mule deer and other mammalian use of the area principally by diversifying habitat (creating favored ecotonal areas) and by releasing forage plants from competition with closed canopy pinyon-juniper. Consideration has also been given to retaining adequate cover for this and many other species of animals. Decreasing canopy cover will render the area more usable to raptorial birds as few raptor species inhabit unbroken forests (Hammerstrom, 1974). Many species such as the Cooper's hawk nest in woodlands but hunt in edge or open habitats.

Ecotones are known to benefit many species of animals and support greater diversity than homogeneous communities (Pianka, 1971). Increasing the amount of dead wood while retaining standing dead trees should improve habitat for woodpeckers (Snyder and Snyder, 1975; Curtis and Ripley, 1975). Snags provide perches and foraging surfaces for these and other insectivorous birds. Subsequently, small raptor species may nest or roost in the holes drilled by woodpeckers. In particular, kestrels and nearly all small owls are dependent on such cavities (Snyder and Snyder, 1975).

Increased dead wood will also affect invertebrates. Wild bees in the area rely on dead wood for nesting sites. In a more negative vein, dead wood also provides oviposition sites for woodboring insects. Rivnay (1964) reported that in several cases an increase in available dead wood resulted in an increase in borer populations from low numbers to a level of economic injury. Carpenter any populations may also increase (Sanders, 1970).

It is anticipated that cottontail hunting will increase somewhat with increasing human populations in the area. Cottontail use of modified pinyon-juniper woodlands with moderate forb and shrub production and additional structural habitat offered by brush piles and windrows showed up to a 47% increase over that found in unmodified areas (Kundaeli, 1964). Small mammal species diversity and abundance is generally high in ecotonal areas (Baker and Frischknecht, 1973) and lizards might be benefited by increased areas suitable for sunning in close proximity to the protective cover of deadfalls and brush piles. Mammalian and avian predators would be benefited by increases in small mammal populations.

2. Sagebrush Conversion - Dense stands of sagebrush will be converted to grass and forb production in the bottomland sagebrush type within (Phase I) and adjacent to (Phase II) Tract C-a, and in the upland sagebrush type along ridges to the west of and on the tract (Phase II and Figure 9-11-1). Methods of sagebrush control are limited by practical, ecological and legal considerations. Control by herbicides on public lands is banned in the Piceance Basic by an injunction obtained by the National Resource Defense Council, Inc. until the completion of an Environmental Impact Statement in fiscal year 1979 (John Clark, 1976, BLM Regional Office, Denver, personal communication). Burning, although it may leave a firm, clean seedbed is ultimately beneficial to

rabbitbrush and injurious to finer bunchgrasses and suffrutescent forbs (Blaisdell, 1953). Chaining or cabling, though inexpensive, results in only partial removal, and methods such as plowing, harrowing, or root cutting cause excessive soil disturbance. Therefore, the following methods will be implemented.

a. Bottomland Sagebrush Conversion - During Phase I, rank stands of sagebrush in valley bottoms on tract will be removed in discrete segments of no more than 24 ha (60 A). During Phase II, stands of sagebrush adjacent to the tract, upon recommendation and approval by BLM and the Colorado Division of Wildlife, will be removed by "railing". During sagebrush conversion activities, considerations will be given to known sage grouse nesting and lek (strutting ground) areas (no sagebrush manipulation will be conducted in these areas).

In order to remove dense sagebrush, heavy steel rails constructed in an " " shape (or alternative available design) will be dragged in opposite directions through the sagebrush by a crawler tractor. This operation will be conducted prior to site preparation during late summer when the sage is most dry and brittle. Follow-up treatments will be administered as needed in subsequent years with a tractor-drawn roto-beater.

This mechanical treatment will release the native grasses which currently persist as understory species from competition with the more dominant shrubs. In some cases, if grasses have not persisted in adequate numbers, it may be necessary to follow treatment with reseeding by drilling. Additional treatment of this nature should be minimal as areas to be converted will be carefully selected. In general, most bottomland sagebrush habitats contain sufficient numbers of desirable species. These bottomland sites are potentially the most productive forage situations in the study area.

The conversion of dense, bottomland sagebrush stands to grasses will substantially increase carrying capacity for livestock and other mammals, thus conpensating for the decrease in livestock range as a result of oil shale development.

Other species of wildlife are expected to benefit directly from bottomland sagebrush conversion. Marsh hawks and other raptorial birds may utilize the area more effectively as a hunting ground. Small mammals, while still maintaining high abundances in unmodified bottomland sagebrush stands may show increased species diversity in response to habitat variety, and cottontail rabbits should increase with greater herbaceous production and the structural habitat offered by windrowing railed sagebrush. In the spring, mule deer may take advantage of new, green growth on sagebrush conversion locations.

b. Upland Sagebrush Conversion - As no dense stands of upland sagebrush currently exist on Tract C-a, upland sage conversion will be restricted to Phase II habitat enhancement procedures. Upland sagebrush conversion will be conducted with the cooperation of BLM.

In order to convert sagebrush stands to a more productive habitat, a tractor-drawn roto-beater will be used to thin dense stands of sagebrush in upland areas. Total removal of large areas of sagebrush will not occur. Stands chosen for manipulation will meet the following criteria:

- live sagebrush crown cover must be greater than 60%
- treatments will be limited to mesa tops or moderate south-facing slopes
- no treatments will be within 3.2 km (2 mi) of known sage grouse strutting or wintering grounds

Suitable locations for upland sagebrush conversion will be selected with the cooperation of BLM and AOSO. Treatments will consist of a roto-beater cutting irregular swaths no wider than 6 m through the sage. Concentrations of serviceberry, mountain mahogany, and bitterbrush will be avoided. Cleared swaths may cross one another forming a mosaic of cleared and uncleared patches and strips, but at no time will more than 50% of the brush be removed. These corridors provide excellent access to feeding areas by sage grouse broods.

Upland sagebrush conversion will be accomplished during late summer when sage is most dry and brittle and the breeding season is over for most bird species inhabiting the area. At the time of treatment, certain cleared areas will be seeded either with or in combination with sand dropseed (Sporabolus cryptandrus) and crested wheatgrass (Agropyron cristatum) at a rate of approximately 9 kg/ha (8 lbs/A) by a rangeland drill. Sand dropseed and crested wheatgrass are uniquely suited for early spring growth and can furnish green forage for livestock and big game well ahead of native species. Mule deer will be able to exploit this new source of nutrients as they migrate through these ranges.

Selective cutting of dense stands of sagebrush may potentially increase sage grouse use of the area. Stands of 20-30% canopy coverage are most frequently selected for nesting (Patterson, 1952; Klebenow, 1969) and brood-rearing was found in areas with an average canopy cover of between 14-25% (Eighth Western States Sage Grouse Workshop, 1973). Sage grouse winter concentrations have generally been located in the "greater than 20%" sagebrush canopy coverage class (Eng and Schlandweiler, 1972; Wallestad, 1972).

Selective cutting of sagebrush stands may prove to be beneficial to other animal species as well, as it will provide a more heterogeneous mosaic of vegetation types than a nearly pure stand of sagebrush. Generally, the greater the variety of vegetative strata available, the greater the potential for increased species diversity (Pianka, 1971).

3. Structural Habitat Construction - The construction of various forms of structural habitat is envisioned at this time to be limited primarily to the occasional placement of slash and woody debris, resulting from habitat modification and construction activities, into protective cover to many species of small birds and mammals as well as lizard species. The sagebrush lizard, the most abundant reptile in the study area, was found to use deadfalls as protective cover; brush piles will serve this same function. Protection from adverse weather and/or predators is vital to many species of animals and is a critical factor in habitat selection by some species. These structures will also provide perches for many songbird and small raptor species. Perches either elevated above most of the vegetation or at least providing a view of much of an area are critical to territorial establishment of many breeding songbirds (Verner, 1975).

The principal purpose of constructing brush piles, however, will be to encourage cottontail production. Although cottontails are not now fully exploited and supply exceeds demand in Colorado as a whole (CDOW, 1974b), it is anticipated that increased human populations will increase hunting pressure on this popular small game species. Existing liberal seasons and bag limits further the likelihood of this expectation.

All materials suitable for brush pile construction removed in site preparation for the mine, conveyor and transmission corridors, buildings, parking lots, reservoirs, holding ponds, roadways, etc. will be used to improve protective cover for wildlife species. Materials will be removed at least 50 m from construction activities and potentially hazardous situations such as roadways and placed on or immediately adjacent to areas to be rehabilitated; care will be taken to assure such practices are not counter-productive to revegetation efforts and assure that wildlife are not drawn to hazardous areas. Slash and woody debris may, at the discretion of the RBOSP Supervisor, be removed some distance and formed into brush piles in suitable habitat.

Additionally, other structural features such as snags, used for perches by raptorial birds, will be left standing during habitat modification activities. Finally, fences, while not constructed for this purpose, may be beneficial to small raptors and insectivorous passerines in areas where there are presently no perches.

4. Water Developments - If mine dewatering causes any spring important for wildlife to go dry, RBOSP will, upon the approval of AOSO and RBOSP supervisor, augment such water loss. This water loss may be partially replaced through the use of permanent runoff collectors ("gallinaceous guzzlers"). Areas containing good habitat for wildlife (especially sage grouse) but presently fails to support wildlife due to lack of nearby water, may be enhanced through the use of runoff collectors.

The number of runoff collectors (guzzlers) to be used and their exact locations will be determined by the RBOSP supervisor in charge. Sites selected for guzzler placement will be on gently sloping, north-facing aspects in order to minimize solar radiation, evaporation, and water temperature. Guzzlers will be placed in areas of relatively low cover, immediately adjacent to high cover. The low cover will allow animals to detect approaching predaotrs, while the high cover will afford protection for fleeing individuals.

Each guzzler will consist of three basic components: the apron, the cistern or tank, and an enclosed ramp. Guzzler water-catchment aprons will measure 3.6 x 6.0 m (12 x 20 ft), an area calculated to collect sufficient rain or snowfall to fill the 3,400-liter (900-gal) tank, assuming annual precipitation equals 25 cm (10 in). The apron will slope gently (5%) toward a lip on the lower end which terminates in a screened drain paved with asphalt to prevent ice build-up during spring thaws. The tank beneath this drain will be 1.2-m (4-ft) wide, 1.2-m (4-ft) high, and 1.1-m (3-ft) long, with a 3-m (9-ft) cover ramp sloping into the frinking chamber at a 30^0 angle and constructed of fiberglass. The sloping area will have molded steps so a diversity of animals can use the water. Fences (3 strand barb wire) will be constructed to prevent livestock utilization of the water.

There may be disadvantages to these structures that outweigh the advantages already propounded. A continued scrutiny of the guzzlers will disclose any serious detriments. For example, coyotes and other predators, including hunters, may exploit the concentrations of grouse and other small animals coming to water to a point where benefit is negated. If this is demonstrated, contingency plans to construct a predator-proof chain link fence will be enacted. Conversely, if the guzzlers prove to be overwhelmingly beneficial, additional ones will be considered.

Screens covering drains will be removed and cleaned each spring to prevent stoppage.

As previously discussed, existing water sources and associated riparian communities in the Tract C-a area are liable to be reduced as a result on mine dewatering. However, pumping may be required to maintain water levels of Stake Springs, the major riparian community in the area. The overall ecological consequences of this surface water reduction are expected to be minor. If adequate Stake Springs water levels are maintained, then the overall effect of mine dewatering on riparian communities in the area is expected to be minimal.

Artificial ponds or wetlands are not currently planned as part of wildlife habitat enhancement measures because of their extremely artificial nature, the uncertainty of their success, and their lack of ecological justification.

5. Habitat Restoration - Inherent to the restoration of habitat and wildlife carrying capacity of disturbed areas will be a successful revegetation program. Therefore, the Wildlife Management Plan will be implemented in coordination with the Revegetation Program (Chapter 8.4). The RBOSP supervisor in charge will insure interaction between both programs and provide a proper balance between revegetation for soil stability, aesthetics, and wildlife values.

As a result of Stage 1 Phase I mining on Tract C-a (6 years), 90 ha (225 A) of the processed shale disposal pile on 84 Mesa will require revegetation. The disposal pile area will increase to approximately 1640 ha (4050 A) over an expected 40-year period. Also during Phase I, approximately 93 ha (230 A) are expected to require revegetation as a result of construction of support facilities (roads, pipelines, conveyor lines, water control facilities, etc). The need for revegetation of areas not related to the disposal area should not significantly increase in Phase II, since most of these areas of disturbance will not be expanded.

Revegetation of areas disturbed during support facility construction will be as soon as possible following completion of construction activities. Reclamation of processed shale disposal piles will proceed as each area within the pile is readied for revegetation. The plant species to be seeded for revegetation will be broadly adaptable to a number of vegetation types. The seeds will be sown in a composite mixture of woody plants, forbs, and grasses, or as a pure mixture of woody plants, forbs, or grasses depending on the requirements of the site to be revegetated. The revegetation efforts will be monitored throughout the lifetime of the program and any areas not adequately revegetated, as determined by AOSO and/or BLM will be reseeded. Successful revegetation of the disposal pile will provide additional habitat to fauna.

B. Aquatic - At some time during the project, a water control reservoir may be constructed in Corral Gulch. This reservoir will provide approximately 1600 m^2 of additional aquatic habitat. Conceptual approximations of the reservoir configuration indicate that the reservoir will attain a normal depth of 30 ft at the dam and a depth of 50 ft during flood stage. Thus, the physical nature of this habitat will be much different than any existing habitat on or near Tract C-a. Because of the depth of this body of water, it is anticipated that the biota of the pelagic areas will include truly planktonic taxa characteristic of alkaline habitats; and that the number of planktonic species and individuals will generally be greater than that found in existing habitats. The aquatic biota of the littoral areas of the reservoir will include algal and macroinvertebrate taxa found in existing habitats, as well as algal and zooplankton taxa which are truly planktonic. The abundance and occurrence of organisms in these littoral areas will depend upon the frequency and extent of fluctuations in water levels of the reservoir. Water quality of reservoir waters will approximate that of the upper aquifer (specific conductance = approximately 1300 μmhos).

11.8 HUMAN DISTURBANCE CONTROL

It is anticipated that a substantial negative impact to many wildlife species not removed or displaced by habitat destruction will occur as a result of increased human activity in the Tract C-a area. The greatest potential for this problem will be during the construction phase when many construction workers will be present. The magnitude of this disturbance will be minimized to a large extent by instituting a human disturbance control program to be overseen by an RBOSP Supervisor. The impacts and associated mitigative measures may be divided into the following categories for discussion:

- vehicle-animal collisions
- legal wildlife harvests
- illegal wildlife harvest

- off-road vehicle use
- harrassment by humans and companion animals

A. Vehicle-Animal Collisions - Increased traffic along access roads, as well along existing and planned roads and trails in the tract C-a vicinity, will result in increased wildlife mortality due to vehicle-animal collisions. Mule deer road kills are of principal concern because of the loss of a valuable big game animal, the likelihood of vehicle damage and the possibility of human injury.

Mule deer and many other animals are most active during the morning and early evening hours; this period of activity coincides with the time that most commuting employees are likely to be traveling the roads. The potential for wildlife loss due to road kills will be reduced through the implementation of the following mitigative measures:

1. Speed Limits - Speed limits will be posted and enforced by RBOSP on tract.

2. Fencing and Underpasses - The unknown effect of migration diversion structures on the mule deer population, the high cost of installation of deer-proof fences and underpasses, and the possibility that drift fencing may not be the best answer in reducing collisions of vehicles with deer (Bellis and Graves, 1971) all demand caution in recommending fence construction and location in the area to be impacted by Tract C-a development. In addition, the study area is a transition zone (Section 3) for mule deer. There are no well defined migration corridors through the area, rather small family groups traverse the area in a random manner. RBOSP will monitor road kills on the leased areas, and if certain corridors have high road kills, then fencing or some other obstruction will be contemplated. Car pooling and reduced speed limits are probably better approaches for reducing the extent of road kill impact. Measures will be implemented which provide for the construction of animal-vehicle-collision preventive structures if they are deemed necessary. Woodard and Reed (1974) reported if a section of highway has 10 deer-vehicle accidents per mile per year, the cost of 8-foot fencing and associated underpasses would be

equaled by benefits approximately 7 years after installation.

3. Awareness Measures - An important element helpful in minimizing the likelihood of road kills is assuring that people traveling the roads are aware of the problem. Two tactics will be employed to this end. The first will be the installation of signs warning of deer-crossing areas at intervals of not less than 1 mi along the major roads at Tract C-a. Secondly, in periodic seminars designed to inform employees and other people interested in wildlife management concerns, the RBOSP Supervisor will deliver a presentation covering driving habits and animal behavior patterns as related to vehicle-animal collisions.

B. Legal Wildlife Harvest - The influx of people into the Tract C-a area as a result of oil shale development will introduce a concomitant increase in resident hunters, trappers, and ultimately an increase in hunting and trapping pressure on the area's wildlife. Whereas the Piceance Basin has long been renowned for its quality mule deer hunting, only light hunting pressure has been relaized on elk or on small game species, namely the cottontail, mourning dove, blue grouse, sage grouse, and various waterfowl species. The coyote is currently the predominant fur-bearer trapped in the basin.

Wildlife habitat manipulations implemented on lands under the jurisdiction of RBOSP (discussed in 11.7 WILDLIFE HABITAT ENHANCEMENT) will attempt to improve wildlife food and cover, and hence productivity of game species. Finally, RBOSP will, in accordance with lease stipulations, post in reasonable and conspicuous places notices informing its employees, agents, contractors, subcontractors, and their employees of all applicable laws and regulations governing hunting, fishing, and trapping. This topic will also be the subject of a periodic wildlife seminar conducted by the RBOSP Supervisor.

C. Illegal Wildlife Harvest - Greater numbers of people in the Tract C-a area will result in an increase of human-wildlife encounters which will, in turn, increase the potential for game violations in the area through increased opportunity and temptation. Interviews with local ranchers and construction workers in the area reveal that considerable poaching occurs in the basin already. Game department officials in several western states have noted a substantial increase in poaching in areas where mining activities are accelerated (Dr. J. Schmidt, Colorado State University, personal communication, 1975). Unfortunately, while game violations are not generally condoned, citizens are reluctant to report violations by their neighbors or co-workers.

RBOSP will consider conviction of a job-related big game violation by any employee as grounds for disciplinary action. Hopefully, the general wildlife knowledge gained as a result of wildlife seminars and other educational programs devised by the RBOSP Supervisor will foster a concern for the native wildlife and aid in the curtailment of wildlife violations.

D. Off-Road Vehicle Use - Although much of the Piceance Basin has been subject to off-road recreational vehicle use for many years, the high degree of public concern warranted by oil shale development will bring the continuation of this practice in the Tract C-a area under scrutiny. The unrestricted use of off-road vehicles has in many cases contributed to the deterioration of an area's wildlife resource through habitat destruction, erosion, and disturbance to the animals themselves. Indiscriminate use of snow machines can damage plants and soil stability directly by crushing plants and disturbing soil, or indirectly by compacting snow. Most importantly, unrestricted snow machine use offers potential for serious harassment of deer, elk, and feral horses during their most critical time of year.

Off-road vehicle use (including snow machines) by employees of RBOSP and their contractors during working hours will be strictly prohibited on lands under the jurisdiction of RBOSP except for certain approved activities.

Off-road vehicle use by the general public is probably permissible by lease provision even within tract boundaries, but could be controlled through cooperation with AOSS, BLM, and CDOW.

E. Harassment by Humans and Companion Animals - The presence of people and companion animals moving about on foot may in some cases have a much more serious effect upon the distribution and behavior of wildlife than do the buildings, equipment, and vehicles normally accommodating these people and their pets.

While the public will be allowed access for all lawful non-consumptive and consumptive wildlife uses in unrestricted areas of the tract as provided by the lease stipulations, unnecessary disturbance of wildlife by RBOSP personnel will not be tolerated.

Other tactics will be invoked to minimize unnecessary disturbance of wildlife by the presence and movements of humans and their companion animals. They are: informative educational presentations to workers by the RBOSP Supervisor on the adverse effects of wildlife harassment and the prohibition of employees' pets running at large.

11.9 MONITORING PROGRAM

A comprehensive monitoring program has been developed to: (a) identify unanticipated impacts of oil shale development, and (b) assess the effectiveness of wildlife management procedures on management species (e.g., mule deer) and the secondary effects of these activities on other ecosystem components. A detailed description of the monitoring program is presented in Section II, Chapter 4, and Section 11, Chapter 5 for terrestrial and aquatic components, respectively. A brief overview of terrestrial monitoring program elements which relate to wildlife management concerns is presented here.

A. Terrestrial - A wide range of sampling activities will be conducted at regular intervals within each of the habitat enhancement areas. These activities will emphasize management species but will encompass methods to assess changes at all levels of ecosystem organization. Control sites will be established in three locations not expected to be affected by oil shale development to provide important information on the natural variation that occurs in biological parameters regardless of man-induced effects. Response in measured biological parameters at habitat enhancement sites will be compared against the control sites to determine the effectiveness of enhancement procedures and the secondary effects of habitat manipulation on ecosystem dynamics.

1. Vegetation - A permanent phytosociological transect will be established in each of the three enhancement areas to determine structural and compositional vegetation changes that result from habitat enhancement procedures. Investigations will be conducted each year at the height of the growing season, approximately mid-June to mid-July.

A modification of the line-strip technique as described by Woodin and Lindsey (1954), Lindsey (1955), and Potter (1957) will be used during the phytosociological investigations.

a. Tree and Shrub Strata - A taut 30-m tape, defining the centerline of the transect, will be used to determine the foliage intercept distance along the line for each of the 100-m transects. In addition to recording foliage intercept, a count will be made of shrubs, seedlings, and saplings of each species occurring within approximately 3 m (9.84 ft) on either side of the tape measure. The 3-m distance from the tape will be measured with a meter stick at the start of each transect and measured again when distances of individual shrubs or trees are in doubt. Density values for shrubs and for seedlings and saplings of tree species will be determined from this census. Census data will be collected and recorded by 20-m (65.6 ft) segments of the transect, effectively making a series of five quadrats approximately 20 x 6 m (18.7 ft). This series of quadrats will serve as the basis for frequency values for the shrub and tree strata.

For mature trees located in each quadrat, the diameters will be recorded in centimeters. The enumeration of these recorded entries will serve in determination of density in the mature tree class. Trunk diameters will be recorded for trees over 7.6 cm (3 in). The trunk diameters will be converted later to basal area values. Size-class distribution will also be derived from the recorded measurements of trunk diameters. Tree trunk diameters will be estimated to the nearest centimeter. Due to the low branching habits of both pinyon and juniper, measurement will be made at a height of 0.5 m (1.64ft) (Barger and Pfolliott, 1972) unless the trunk is forked below that level, in which case diameters will be measured just below fork swell and above basal fluting. Straight-boled Douglas-fir and aspen trees will be measured at breast height, 1.41 m (4.5 ft).

For all flowering plants (angiospermae) a phenology code will be recorded to indicate the stage of development for each species observed in a given sampling period: (1) emergent, (2) vegetative, (3) initiation of flowering, (4) flowers fully developed, (5) initiation of fruits, (6) fruits fully developed, (7) dehiscence or dispersal of seeds, and (8) death or dormancy of plant and other factors where deemed applicable.

b. Herbaceous Stratum - Herbaceous cover values will be estimated within a 0.5 x 1 m (1.6 x 3.3-ft) rectangular metal frame quadrat. The long axis of the quadrat will be placed parallel to and on the right side of the centerline tape and centered at 10-m intervals.

Each species will be identified and noted. Plants not identifiable to the species level will be collected at a nearby location and assigned a code number corresponding to the entry on the data sheet. The ground cover of each species will be estimated. Frequency values will be derived from the recorded occurrence of each species in the ten, 0.5 x 1-m quadrats sampled along each transect. Density, or the number of individuals of species occurring in each quadrat, will also be recorded. Density of grasses or grass-like species will not be recorded.

2. Invertebrates - Invertebrate sampling will be conducted at each of the habitat enhancement and control sites to determine the changes that occur in invertebrate population dynamics as a result of habitat enhancement procedures. Sampling methods will emphasize those invertebrate groups that have been shown to be sensitive to man-induced perturbations. These groups include litter and flying invertebrate fauna and western harvester ants. The latter group has been documented as a colonizer of disturbed habitats in studies of the insect fauna of overgrazed areas (Sharp and Barr, 1960; Wheeler and Wheeler, 1963).

a. Litter Fauna - The litter decomposition and litter fauna will be monitored using litter bags as described in Crossley and Hoglund (1962). Each monitoring and control site shall have 24 litter bags containing a known quantity of mixed litter. Every 4 months a litter bag shall be removed from each of the stations, Berlese'd and weighed. The weights shall be recorded and decomposition rates calculated. If there is a significant shift in the decomposition rates, then an investigation shall be conducted for the cause.

The invertebrates obtained from the Berlese extraction shall be classified and enumerated. This information shall be used for sudden shifts in represented taxa and species diversity; any large change in these categories will be investigated.

b. Flying Invertebrates - Population studies of actively flying invertebrates will be conducted using Malaise traps. Sampling will be conducted in May, July, and September at each site.

One trap, as described by Townes (1972), will be placed at each of the sampling sites to capture mobile airborne species. The trap consists of a tent made of dacron netting (10 meshes/cm; 25/in) which is open on two sides and divided in the middle.

A wire fence consisting of four 1.4-m (4.5-ft) posts and two strands of No. 9 gauge wire will be put up around each trap to prevent interference from ungulates. The Malaise traps will be opened on the first day of sampling and checked and insects removed daily for 10 days. Samples will be labeled and logged into the record book and transported to the laboratory for identification and enumeration.

c. Western Harvester Ants - Ant colony density and relative colony vigor rating will be evaluated at each of the designated sampling sites. Colony density will be measured only during the July sampling period. Vigor will be measured in the May, July, and September sampling periods.

Colony density will be estimated by randomly selecting a starting point and compass direction in each site. A transect 164 m (538 ft) long following the compass direction and using a tape measure for distance will be measured off in 33-m (108-ft) increments and permanently marked. Within each increment, harvester ant nests within 15.2 m (50 ft) on each side of the transect will be counted. This will result in five, 100-m^2 (10,760-ft^2) quadrats for which an average number of western harvester ant colonies per hectare can be calculated.

Colony vigor tests will be performed in five randomly selected colonies at each site. Vigor tests will be conducted on the same colonies each sampling period. The method used will be one developed by Race (1964) and modified by Rogers (1972). The method consists of grinding ants in a blender, placing a drop of the resulting liquid near the colony entrance, and photographing the resulting response to the liquid. The camera will be held the same distance above the disc so that the picture will always cover the same surface area, and the picture will be taken one minute after application of the liquid in all samples. To reduce natural variation in ant response to the liquid, temperature, cloud cover and time of day will be duplicated as much as possible during each sample for a particular colony. A count of the ants responding to the liquid will give a vigor rating which can be compared between samples, sites, and sampling periods.

3. Vertebrates - The vertebrate monitoring program is designed to assess changes in vertebrate population structure and dynamics that result from wildlife management procedures. The effectiveness of habitat enhancement procedures for management species, as well as the secondary effects of habitat enhancement on other components of the ecosystem, will be determined.

a. Small Mammals - A live trapping program will be conducted at each of the habitat enhancement and control sites. To coincide with periods of high small mammal activity and to provide reliable data on population size, survivability, immigration, recruitment, productivity, and other population parameters, sampling will be conducted during May, July, and September. Within each sampling site two parallel lines of live traps will be established 15 m (50 ft) apart. There will be 20 trap stations, 15 m (50 ft) apart with two "Sherman" type live traps at each station.

Traps will be baited with a mixture of peanut butter, rolled oats, and cracked corn, and will be checked for 3 consecutive days during each of the sampling periods. To minimize desiccation and death of trapped animals from solar radiation, cardboard will be positioned over each trap in a Λ shape to provide shade for animals captured. A wad of dacron, wool, or cotton batting will be placed at the back of each trap for bedding material to provide further insulation.

Traps will be reset and rebaited as necessary. All animals captured will be distinctively marked by unique toe-clipping combinations and released. For each animal captured, the species, sex, age class, weight, reproductive status, general physical condition, capture location, and animal identification number will be recorded on a standard trapping form. Weights will be determined to 1.0 gm accuracy using a Pesola calibrated spring scale.

b. Lagomorphs - To assess the effectiveness of lagomorph habitat enhancement procedures a road transect (48 km) will be established traversing major habitat types including the enhancement areas. These road transect surveys will be in conjunction with the owl transect program.

c. Avifauna

1) Songbirds - Species, population size, and other population parameters will be determined by the Emlen strip transect method (Emlen, 1971) for songbirds (and certain non-songbirds) at each of the sites during May, July, and September. All transects will begin at a specified small mammal live-trapping station and will be permanently marked.

2) Sage Grouse - Winter ground counts will be employed to assess the effectiveness of sage grouse management procedures. During February, two 32-km (20-mi) road censuses will be initiated near the upland sagebrush conversion area (Figure 9-11-1) and conducted through sage grouse habitats. A 24-km (15-mi) census route located through habitats on 84 Mesa containing gallinaceous guzzlers will be driven for 2 consecutive mornings during February. All sage grouse encountered will be counted, their location plotted on field maps, and birds flushed and sex and ages tallied on field data sheets. Criteria for sexing and aging will be based on data presented by Rogers (1968).

3) Raptors - A 48-km (30-mi) route census will be used to monitor changes in raptor species composition and relative abundance that might result from the habitat disturbance and increased human activity associated with oil shale development. To determine the success of raptor mitigative efforts, the route will include each of the habitat enhancement areas.

The survey diurnal raptors such as hawks and eagles, the census route will be driven on 3 consecutive mornings during February and July, weather permitting. Raptor surveys are conducted during both winter and summer because of seasonal changes in raptor species composition. All raptors observed will be recorded as to species, location, sex, and age if possible.

To survey owls, the same road transect will be driven on 3 consecutive nights, also during February and July. These surveys will commence within 2 hours after sunset. The transect will consist of 30 stops, each permanently marked with stakes and flagging tape, located approximately 1.6 km (1.0 mi) apart. At each stop, the observer will leave the vehicle, walk approximately 15 m (50 ft) away and record on a field data sheet, by species, the number of owls heard or observed during a 5-minute period.

d. Mule Deer

1) Aerial Surveys - Aerial surveys will be conducted to determine relative changes in mule deer distribution and abundance that might result from the habitat disturbance and increased human activity associated with oil shale development near Tract C-a. These surveys will employ a high-wing Cessna aircraft designed to permit slow flight at low levels above the ground. The plane will be flown along standardized transects (flight paths) within the range of 120-136 km (75-85 mi) per hour (indicated air speed) at an altitude of approximately 45 m (150 ft) above the ground. Due to the varied topography, the above-ground altitude may vary slightly within transects; however, the flight paths, speed, and altitude of the aircraft will be duplicated as much as weather conditions permit. Survey flights will be conducted at approximately monthly intervals from late October through early April to assess the mule deer populations during the winter period.

Complete coverage of the area will be accomplished by 13 north-south transects established during the first-year baseline investigations. The flight paths parallel each other at approximately 1.6-km (1-mi) intervals and will be approximately 8.1 km (5 mi) east of Tract C-a boundaries to the ridge along Cathedral Bluffs west of Tract C-a.

2) Pellet Group Counts - Pellet group counts will be used to monitor the effectiveness of habitat enhancement procedures. Pellet group counts have been used by many researchers to census big game, indicate population trends, and determine distribution patterns of big game animals (Bennet, English and McCain, 1940; Julander, 1958; Harris, 1959). The technique involves counting the number of pellet groups deposited during a known time period on an area of known size. This information, coupled with a knowledge of big game defecation rates, can be used to compute the levels of deer use in an area. Several researchers have published defecation rates and other pertinent information on study design, techniques, and field procedures for big game studies (Rogers, Julander and Robinette, 1958; Smith, 1964; McKean, 1965; and Neff, 1968).

Five randomly selected pellet group transects will be established within each of the six habitat enhancement types within 6 months after habitat modification is completed. The distance between plots will be varied to allow all 25 plots on each transect to be located entirely within the modification areas. Plots will be inspected annually during the spring and data compared to pellet plot transects established in relatively undisturbed areas (Zone 3 above) to establish relative mule deer habitat use patterns.

Each transect will consist of 25, 9.3-m^2 (100-ft^2) circular plots spaced at regular intervals along a straight line course. During transect establishment, a 45.7-cm (19-in) rebar stake will be driven into the ground to mark the center of each plot. The distance between plots on the transect will be measured with a tape measure along a compass course. An aluminum pole, slipped over the rebar stake, will serve as an axis for a rope marked 1.72 m (5.64 ft) from the center of the stake. When the rope is revolved around the pole, the mark delineates the plot boundaries. A short written description of vegetation and landforms will be recorded for each plot during transect establishment. All old pellets will be cleared from the plots during the establishment phase. Plots will be inspected annually during the spring and pellet groups deposited during the census period will be counted, removed, and recorded on field data sheets.

RBOSP is presently reviewing a plotless method for determining mule deer abundance and distribution. If this technique is applicable to the Tract C-a environs, then RBOSP will contemplate substituting this method into the second year of baseline program.

B. Aquatic - Since the intent of the RBOSP water quality control plan is to avoid disturbance of the existing water quality and the flora and fauna of aquatic habitats, monitoring of aquatic habitats will aid in assessing the effectiveness of water controls. The aquatic monitoring program is discussed in detail in Section 11, Chapter 5.

11.10 QUALITY ASSURANCE AND ADMINISTRATION

A comprehensive Quality Assurance Program will be instituted as an integral part of the Wildlife Management Plan. Its internal function will be fulfilled by the RBOSP Supervisor. Quality assurance functions will have both formative and regulatory roles in the plan, providing initiative, input, and control throughout all phases of its subsequent development.

The RBOSP Supervisor will function as administrator directing performance of the plan and serving a quality assurance function over those portions of the plan that must be administered by others (such as dust control, noise abatement, etc.). This supervisor's two-fold function may be viewed as operating in three specific phases:

- pre-implementation planning
- implementation
- review and modification

A discussion of capacities in each of these phases follows.

A. Pre-Implementation Planning - The Wildlife Management Plan as presented herein will undergo comprehensive review by the RBOSP Supervisor prior to implementation. This person's responsibility as plan administrator demands thorough knowledge of the Detailed Development Plan as well as the Wildlife Management Plan. The supervisor will take the time to carefully review the plan and to pursue possible improvements in the plan prior to its implementation. Early establishment of performance standards will assure standardization of procedures and will aid in planning equipment needs and monetary allocations as well as foreseeing possible problem areas unique to a specific planned activity.

The RBOSP Supervisor will also assure that proper channels of communication and information flow and mechanisms for efficient and timely meeting of objectives are incorporated into the plan. As part of development of the administrative structure for the plan, an efficient and comprehensive duplicate file system will be established. This file system will provide for limited-access storage of originals of unique and irreplaceable documents while a free-access, comprehensive working file will supply working needs throughout the plan.

B. Implementation - The RBOSP Supervisor will serve as an independent regulatory agent to assure that the expressed objectives of the plan will be met by the proposed plan activities. Nature's variability and the prototype character of this development almost assure that the plan will require some degree of modification. The RBOSP Supervisor input into this process based on a comparison of observed task performance results with stated objectives will initiate such modifications.

C. Plan Review and Modification - Regular review of the Wildlife Management Plan will be scheduled and undertaken as presented in 11.11 PERIODIC REVIEW. The RBOSP Supervisor will have continuous input into this review process and will have the responsibility of assuring that plan modifications are planned and scheduled under the same specificity constraints as described above.

11.11 PERIODIC REVIEW

The Wildlife Management Plan, as presented herein, must be viewed as a dynamic strategy to reduce the negative impact of oil shale development on the wildlife of the Tract C-a area. As the prototype development advances, a more effective management plan than that described herein, one derived from specific experience, will evolve.

The monitoring program and qualitative evaluation will provide an indication of the degree of effectiveness of wildlife management procedures. Through these indicators, performance standards will be derived as wildlife management concepts evolve concomitant with prototype development. In the event that the procedures are shown to require major modification in order to more effectively meet the objectives of the plan, the RBOSP Supervisor may, at any time, initiate procedures for evaluating performance achieved under this plan. Sequence of evaluative procedures is: (1) internal, RBOSP staff, and (2) by Area Oil Shale Supervisor's Office. At each level of evaluation, an opportunity for feedback will exist so that both the current operation plans and general conceptual plan can be modified as necessary. The objectives of these evaluative procedures will be to determine whether or not wildlife management activities are adequate, and how they can be improved.

In any case, the plan and any procedures in effect as a result of the plan will undergo comprehensive review under the sequence of evaluative procedures as outlined above, immediately prior to the commencement of the construction phase and the initiation of the plan, and then yearly thereafter during the anniversary month of its implementation.

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CHAPTER 12

PROTECTION OF OBJECTS OF SCIENTIFIC AND HISTORIC INTEREST

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 12
PROTECTION OF OBJECTS OF HISTORIC AND SCIENTIFIC INTEREST

Baseline studies have been conducted to determine if the project area is an area of significant archaeological, paleontological or historic interest. These studies indicate little likelihood that development operations by Rio Blanco will disturb objects of historic or scientific interest. However, because nothing significant was found does not eliminate all possibility that some important materials do exist, and Rio Blanco will take measures to protect any object of historic or scientific interest that may be found during development, as required by the Federal Antiquities Act. The following is Rio Blanco's plan for protecting these objects:

12.1 SITE PRESERVATION AND SALVAGE

A. Archaeologic - Three classes of site importance were established during the baseline archaeological survey--primary, secondary, and tertiary. Briefly, primary sites are those sites having a large number of tools and other artifacts. They probably represent seasonal occupation, and excavation could possibly yield more artifacts. Secondary sites have less material than primary sites, probably represent areas of short-period occupation, and have low priority for excavation. Tertiary sites are characterized by a very few artifacts and, while they indicate man's use of the region, they probably do not represent camp sites (More complete definitions and a map of the study area are presented in Section 3, Chapter 10).

During development operations Rio Blanco will avoid, where practicable, archaeological sites. Primary sites will be excavated prior to disturbance by development operations, and further study will be made of secondary and tertiary sites before, or during, disturbance if they fall within areas affected by development operations.

B. Paleontologic - No paleontologic finds have been observed on the surface on or around Tract C-a that are presently judged to be significant. In the subsurface, a review of tract core hole lithologic description logs disclosed the presence of sparse small fish remains in three core holes, however, these remains are not unique to Tract C-a. A literature review was also conducted but nothing significant was found. (See Section 3, Chapter 11, for paleontological baseline study.)

Based on these studies the possibility of discovery of a significant paleontologic find is considered extremely remote; however, in the event of such an occurrence, Rio Blanco will take measures to protect the find if it falls within the area affected by project development.

C. Historic - Recent historic material is largely that left by deer hunters. No significant finds have been identified in the project area, but in the event one is identified, Rio Blanco will take measures to protect and preserve the find.

12.2 EQUIPMENT OPERATOR TRAINING

The primary concern is to avoid damaging historic or scientific material. Operating personnel will be briefed on the archaeological, paleontological and historic resources of the area and instructed to avoid areas of significance. They will be provided with enough information to recognize the presence of historic and scientific resource material, particularly that which is subsurface. In the event potentially significant historic or scientific resource material is unearthed, work will stop in the immediate area until the find is cleared.

12.3 NOTICE OF FINDS

In the event of a significant find during project development operations, notice of such findings will be sent to the Area Oil Shale Supervisor, Bureau of Land Management and the State Archaeologist in compliance with lease stipulations and the Antiquities Act.

CHAPTER 13

ABANDONMENT

SECTION 9

ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY

CHAPTER 13
ABANDONMENT

Disposition of project facilities when operations cease will be influenced by a number of considerations, including:

- Profitability of oil shale operations.
- State of the art in oil shale retorting.
- Usefulness of the facilities to adjacent operations.
- Degree of government participation and/or control in the shale oil industry.
- Degree of project development.

Because of the wide variety of possible abandonment schemes, it is not possible to propose a definite plan of action at this time. The following guidelines will be used to prepare detailed abandonment plans and procedures prior to abandonment activities. Of course, if the facilities should be sold by Rio Blanco as an operating facility, the demolition, salvage and rehabilitation activities would not take place. Also, for a period of six months after termination of the lease, the lessor has the right to purchase at the appraised value any or all items on the lease required or useful for the protection of the leased lands.

Design of the abandonment activities will be governed by the various environmental protection plan concepts. The objective will be to return the site to a stable ecological (not requiring further maintenance) state that will not contribute to continuing environmental deterioration and that will be consistent with the appearance of the surrounding area. All required monitoring programs will continue until the AOSS has determined to his satisfaction that environmental conditions have been established after termination of the development operations which are consistent with the requirements of applicable Federal and State statutes and regulations; however, the AOSS may terminate this requirement at an earlier date when it is in the public interest.

13.1 MINE

A. Phase I - Abandonment of the open pit mine is not anticipated during or after the Phase I operation. However, since adverse economic, technical or environmental factors could cause a shutdown of the open pit mining operation, consideration has been given to an abandonment plan. If cessation of operations becomes a reality, a more detailed abandonment and rehabilitatation plan will be submitted for approval at that time.

The small pit size and few surface acres disturbed limit the number of alternatives available for pit reclamation, since pit backfilling will not have occurred during these early years. Initially a showing of compliance with the terms of the lease by Rio Blanco would be submitted to the AOSS, and, upon its acceptance, a notice of relinquishment would be filed as provided in Section 28 of the lease. Buildings and equipment on the lease would be sold to the government at appraised value or removed by Rio Blanco at government option as prescribed in Section 32 of the lease.

Also, in accordance with the various regulations and lease terms governing abandonment, Rio Blanco would undertake an abandonment plan for the open pit which would have the key elements shown below. This abandonment plan appears reasonable based on current data, although it is presented as only one of several possible alternative plans for abandonment:

- Revegetate the exposed open pit benches.
- Allow the pit to fill gradually with water.
- Create a reasonably acceptable habitat for wildlife.
- Remove mine buildings and facilities or convey them to the government as described above.
- Reclaim surface area disturbed by mining activities, required by Section 11 of the environmental stipulations to the lease, to a state not requiring further maintenance.

The logic behind the first three steps above and their expected effect on the abandonment plan are discussed in the following paragraphs.

It is expected that average pit wall slopes from the ultimate toe to the crest of the Phase I pit will be at angles of 45° or flatter. It is anticipated, therefore, that these pit walls will be generally stable based on rock mechanics work to date and observation of naturally occurring oil shale outcrops. Local sloughing may occur in time at the crest of between-bench slopes and along specific planes of weakness. This is not expected to be a significant environmental or safety problem, however.

As discussed in other sections of the Detailed Development Plan, Rio Blanco intends to carry out revegetation experiments as necessary to establish technology for the successful revegetation of areas affected by Tract C-a development. It is expected that, contingent upon the results of experiments carried out well in advance of pit reclamation, that Rio Blanco would find it feasible to deposit top dressing on pit bench levels and establish viable vegetation aimed at stabilizing and partially reclaiming the pit walls to productive use.

Based on cursory studies to date, ground water inflow and surface water runoff should fill the Phase I pit to about the top of the upper aquifer about 200 ft. above the pit floor, with relatively good quality water (postulated to be similar to the average for the upper oil shale aquifer) in approximately fifteen years. It is expected that the pit would fill at a slower rate above this point, but it is not practical to estimate this rate on the basis of available data. Hydrostatic heads in the lower aquifer are adequate to cause the possible influx of lower aquifer water to the Phase I pit along fractures and/or fault planes. However, it is not believed, based on present data, that such minor inflows, if any, would have a significant impact on water quality in the abandoned pit. It is anticipated, therefore, that the water quality would be conducive to the introduction of plant and animal species which would be benficial to the area.

B. Phase II - Although the likelihood of open pit abandonment during Phase II is perhaps somewhat greater than Phase I, abandonment of the mine is not anticipated during the Phase II operation. However, as with Phase I, consideration has been given to an abandonment plan.

As described for Phase I, a showing of compliance with the lease terms would be made and, upon its acceptance by the AOSS, notice of relinquishment would be filed. The same appraisal procedure would be followed although it may be assumed that the buildings, facilities, and equipment would be far more extensive during Phase II. Such equipment and facilities would either be removed or conveyed to the government at option of the AOSS. As with Phase I, all abandonment plans would be subjected to AOSS approval.

By the end of Phase II, the pit will have extended over a surface area of about 750 acres and to a depth of about 1800 feet. Although it would have significantly increased in size and depth compared to Phase I, only limited backfilling could occur during the 30 years of Phase II production due to the operational requirements of open pit mining. Without pit backfilling as a viable alternative, the following scheme is presented as one possible alternative plan for abandonment:

- Revegetate the exposed open pit benches.
- Reclaim and revegetate disturbed surface areas, required under Section 11 of the Environmental Stipulations to the lease, to a state not requiring continual maintenance.

As for the Phase I abandonment plan, it is anticipated that the Phase II pit walls will be generally stable although extensive local sloughing may occur between benches. It is also expected that, contingent upon revegetation experiments, it will be proven feasible to topdress and revegetate pit bench levels to stablize and partially reclaim the pit walls to productive use.

Ground water inflow and surface runoff into the Phase II pit should very slowly from a lake in the bottom of the pit. After perhaps thirty years, based on cursory examinations, the water would have reached about to the top of the lower aquifer. Most of the water in this lake would have come from the lower oil shale aquifer and it appears reasonable to expect that water quality would be closer to the quality of that aquifer. Contingent upon the results of experimental introduction of flora and fauna, it is anticipated that life forms presently existent in the lower reaches of Yellow Creek could be introduced to the lake; however, this is greatly dependent upon the dissolved solids content of the lake formed.

Rio Blanco would actively seek a feasible means of reducing to acceptable minimums the inflows of water from the upper aquifer into the pit, along with its running down the pit walls and mixing with the lower aquifer water. It is believed that there is a reasonable probability that this could be achieved; however, should this not prove to be the case, the commingling of water from the upper aquifer would take place in the lake at a ratio of about 25% of upper aquifer water to 75% of lower aquifer water. Dewatering of the upper aquifer would also continue. Water quality in the pit can be expected to remain about as indicated by the 25%-75% mixture, since annual inflows due to precipitation are estimated to substantially offset evaporation losses.

C. Ultimate Open Pit - It is believed that a conceptual abandonment plan for an ulitmate pit (total tract) operation should assume waste backfilling against two or more pit slopes along the tract boundary, covering any resource in those areas. Thereby, at the end of total tract development, waste backfilling, (which began after about 30 years) would have reclaimed all of the pit except an area large enough to permit final mining, crushing and conveying operations. This area would probably be on the order of 1000 surface acres in the southeastern corner of the tract.

The backfilled area of the ultimate pit would be contoured and covered with topdressing to control erosion, permit easy seeding, and present an aesthetically acceptable shape. The surface area and pit remaining after backfilling would be allowed to fill slowly with water and would be revegetated similar to the ideas presented for the Phase I abandonment plan. This should in time provide a reasonable habitat for wildlife in the area.

D. Other Long Range Considerations - In the event that open pit mining is to be undertaken on lands adjacent to Tract C-a, the pit remaining on the tract would likely become a substantial asset to the adjacent lessee, by providing a location for backfilling of waste from that operation. This factor should be weighed in any abandonment plan. It does not appear preferable, considering both economic and environmental factors, that backfilling of waste from 84 Mesa into either a Phase II or an Ultimate Open Pit.

13.2 PROCESSING FACILITY

Abandonment of the processing facility will involve several stages.

- All tanks, aboveground steel and wood structures and aboveground piping will be salvaged and removed. Minimum maintenance shops and administration facilities will remain until the final stages near completion.
- All concrete structures will be demolished down to grade level, and all concrete and asphalt surfacing, curbs, etc., will be broken up in place. Hard packed, unsurfaced or temporarily surfaced roads will be scarified and the tight surface broken up.
- Underground piping, culverts and drains will be plugged and abandoned in place. After the connection pipes have been plugged, catch basins and manholes will be filled with earth.
- All concrete foundations, pavements and other manmade features reduced to rubble at grade will be covered with earth. Most of the cover material can be salvaged from dikes and fill areas and, if necessary, excavated within the already-disturbed areas.
- All graded areas will be recontoured through slope rounding, cutting, filling and other earthwork similar to the techniques discussed in Chapter 8. Dikes will be removed, ponds and ditches filled or reshaped, and the land generally restored to a natural appearance. The area will then be revegetated in accordance with the principles established for revegetation in Chapter 8. All these activities will be designed to control erosion and to leave the site in a condition not requiring continual maintenance.

13.3 PROCESSED SHALE AND OVERBURDEN DISPOSAL SITE

Abandonment of this area will require little more than completion of the rehabilitation-revegetation activities that will be on-going throughout the life of the project. Final abandonment activities will include:

- Completion of revegetation and removal of irrigation facilities and temporary fencing.
- Obliteration of access roads (roads which will not be left for public use) and revegetation of the last remaining disturbed areas.
- Reshaping and revegetation of any abandoned ponds, ditches or dikes.
- Creation of a condition not requiring further maintenance.

Phase II operation envisions the use of conveyors to transport the waste material to the disposal site. The first stage of abandonment in Phase II will be the dismantling, salvage and removal of these conveyors. Reshaping and revegetation of service roads and conveyor routes will proceed simultaneously with the final revegetation activities on the disposal site.

13.4 SUPPORT FACILITIES

Abandonment of support facilities will follow the same stages as discussed for the processing facility. If desired, some features such as the following may be left in place for other uses:

- Clean-water impoundments.
- Selected roadways.
- Selected pipelines and power lines

Determination of the facilities to remain, if any, should be made at the outset of detailed planning of the abandonment activities to ensure that some desired facility is not inadvertently destroyed.

Historically, the reclamation efforts for the Water Control Facilities have utilized the use of small check dams in larger water control ditches to prevent further erosion and to partially repair existing damage by allowing the area behind these check dams to silt in.

The future abandonment plans for Tract C-a shall include the filling and packing of any ditches and the leveling of water deversion dikes associated with oil shale activities which do not contain check dams or other flow inhibitors. The filling in of these ditches and leveling of dikes will result in a great reduction if not elimination of gully erosion resulting from oil shale development. Existing reservoirs remaining after abandonment will be allowed to silt in, will again serve as a control against the flow rate in the area, and also will repair a small portion of the area already damaged by gully erosion.

Water quality control ponds such as those downstream from the processed shale disposal site will be allowed to silt in. In the event that a high concentration of soluble salts exist in the ponds a disposal or protection plan will be developed for approval by the AOSS.

A second alternative would be, upon abandonment, to release the reservoir to the proper federal administrative agency. After the proper federal agency has assumed administration of the reservoir they may develop a plan for the best use at that time.

SECTION 10

ENVIRONMENTAL ASSESSMENT

CHAPTER 1
INTRODUCTION

An assessment of environmental impacts is made to determine the effects (both beneficial and harmful) of development on the environment and the living organisms dependent upon that environment within the area proposed for development. Concomitant with describing impacts of development is the responsibility to suggest viable means of lessening or "mitigating" harmful impacts. Sectors of the environment which will be affected by oil shale development on Tract C-a include air quality, surface and sub-surface water supplies (hydrology), the aquatic environment, and the terrestrial environment.

Assessment of environmental impacts for each of these areas is accomplished by identifying the source of the impact, then discussing the nature, severity, and longevity of the impact. Appropriate mitigation measures are suggested for harmful impacts, and their predicted effectiveness is described. The net harm to the environment after mitigation is described as negative unavoidable impacts.

Since the proposed development is a long-range program, during which periods of impact will vary considerably both in nature and extent, the assessment is partitioned by phase of development and type of activity for each of the environmental areas.

Phase I covers the first six years of operation where first one retort is operated for three years, then a second retort is operated during the next three years. The Transition Phase covers the period during Phase I in which construction of the full-scale commercial facility is underway, while operation of the two retorts continues. Maximum human presence (with the attendent possibility of human disturbance) occurs during this period of time. Phase II is the full-scale commercial operation at a production rate of 55,800 BPSD.

Assessment of impacts on air quality are included as a part of the discussion on atmospheric dispersion modeling in Section 9, Chapter 5, and are not repeated here. The major impact on the hydrologic environment will likely be caused by mine dewatering and is discussed in this chapter. The effects on the aquatic and terrestrial environments are discussed in relation to all the engineering operations and major development activities.

CHAPTER 2
AIR

The assessment of the impact of Rio Blanco's operations upon the air quality in the area surrounding Tract C-a has been predicted by atmospheric dispersion modeling techniques. The description and results of the modeling are presented in Section 9, Chapter 5 as part of the Air Quality Control Plan and will not be repeated in this section.

CHAPTER 3
HYDROLOGY

The engineering and the design of the Tract C-a mine and facilities are based on zero discharge of water. Based on this principle the environmental effects on the water quality resulting from discharges are kept to a minimum. This chapter reviews the unavoidable effects on the hydrologic environment during the mining phase.

3.1 MINING

A. Precipitation - Precipitation should be little affected by the mining or other associated activities. Some effects may be caused by localized topography changes (disposal pile and open pit mine) and the small increase in ambient particulate concentration. The variation in precipitation due to the above would be negligible.

B. Springs and Seeps - The dewatering of the mine may have an effect on some spring and seep flow rates in the vicinity of the Phase I and Phase II mines. The springs and seeps most likely affected are shown on Figure 3-4-21. The dewatering studies indicate that these possible effects would begin after two years of dewatering. It appears likely that after several years of dewatering, flow from some of these springs and seeps could be reduced.

C. Streams - As determined by the baseline studies, the streams on Tract C-a are intermittent. The intermittent flows in Dry Fork (Phase I and II) and Corral Gulch (Phase II) would be diverted around the mine(s) and associated facilities. These diversions would probably reduce the sediment load due to the less steep gradient and would be desilted as required. Energy dissipators, as discussed in Section 9, Chapter 6, are planned to reduce erosion on the downstream end of the diversion structures. The dissolved solids concentration would remain relatively unaffected by the diversions.

During the construction phase of the project a potential for increased sediment load in the intermittent streams exists. However, engineering design and construction practices as outlined in Section 9, Chapters 5 and 6 would minimize this potential problem.

Dewatering of the open pit mine, as projected by the ground-water model, may reduce the ground-water discharge to the stream systems. As shown on Figure 10-3-1, the only stream system subject to a projected major environmental impact would be Yellow Creek. The model predicts that, after 30 years of dewatering the ground-water discharge to Yellow Creek would be reduced 50 per cent. The Yellow Creek flow rate could be reduced 80 per cent by the tenth year of dewatering as indicated by the model and engineering studies. It is anticipated that, intermittent flow totaling about 20 per cent of the present flows near the White River would be sustained throughout the Phase II dewatering.

The RBOSP basin model indicates Piceance Creek and some of its tributaries will also be impacted by Tract C-a dewatering. As shown on Figure 10-3-1 Black Sulfur Creek is predicted to experience a reduction of 2.99 cfs in the ground-water discharge at the end of 36 years of dewatering. The projected effect on the rest of Piceance Creek and its tributaries is less than one-half of the effect on Black Sulfur Creek. Based on surface water flow data from these streams, it is anticipated that the effect would be reduced flow and not cessation of flow.

The reduced ground-water discharge of saline water, as a result of the mine dewatering, would have a possible advantageous effect on the environment. This reduced ground-water discharge would result in reduced flows of the saline waters of Yellow Creek and Piceance Creek thereby reducing the amount of salt discharged to the White River.

1. Mitigative Procedures - As part of the RBOSP augmentation plan now pending in the Division 5 Water Court, RBOSP has proposed the following methods to reduce the possible impacts on the surface water in the basin:

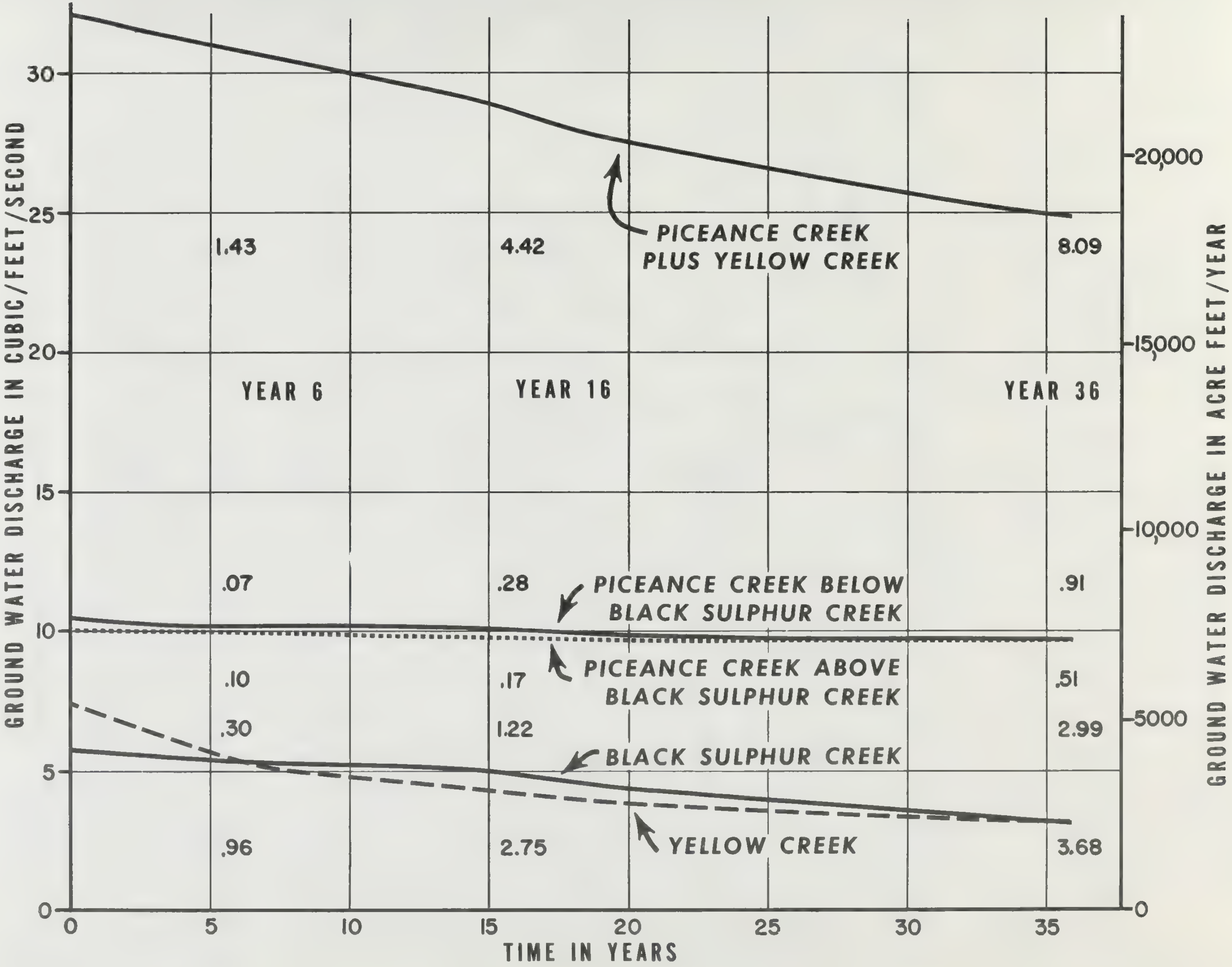

Figure 10-3-1

EFFECT OF PUMPING ON GROUND-WATER DISCHARGE TO STREAMS OF THE PICEANCE CREEK BASIN

- Water replacement by means of water delivery system from RBOSP water rights;
- Water from existing water rights to be released to the stream;
- Water from ground-water sources to be made available to the stream.

The legal issues of this court case have not been decided. The court case is scheduled to be tried in late May, 1976. It should be noted that, in the State of Colorado, this legal procedure is the normal method of dealing with water rights.

D. Alluvial Aquifers - As determined by the hydrologic baseline studies, alluvial material is located along many of the stream valleys. It is only in the major tributaries that the alluvium was found to contain water. The wells drilled in the alluvium have relatively low yield and are used for domestic livestock, industrial and irrigation purposes. The engineering studies indicate that water levels in some wells may be lowered during Phase II dewatering. However, it is anticipated that the present well production rates could be maintained.

E. Deep Aquifers - The two deep aquifers determined by the hydrologic baseline studies would require dewatering as previously discussed. This dewatering, as projected by the basin model, would lower water levels in both aquifers over much of the basin. The amount of head change is a function of time, distance and the rate of mine dewatering. The projected head changes for Phase I dewatering are shown on Figures 10-3-2 and 10-3-3 for the upper and lower aquifers respectively. The State Engineer's Records show only seven deep wells within the area of projected water level changes. All seven of these wells are located near the contour of zero change.

Projections for the Phase II dewatering impact have been made. However, due to the inherent vagaries of ground water, these projections are less reliable than the Phase I projections. The model indicates that the above-mentioned seven wells would experience a decreased water level of about 50 feet at the end of the Phase II dewatering. This projected change in head would not significantly impact any of these wells from maintaining their present production rates.

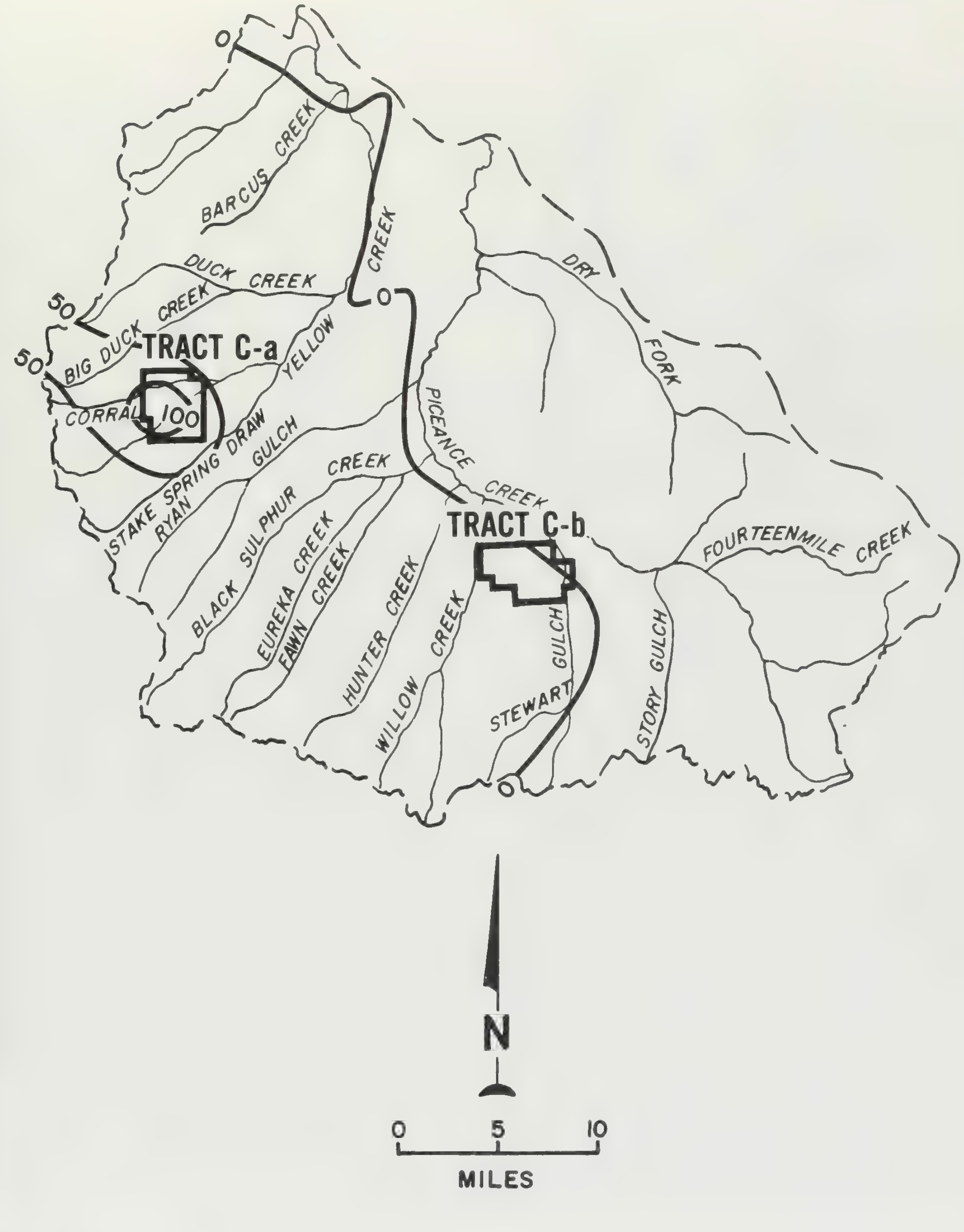

Figure 10-3-2

PHASE I UPPER AQUIFER FOOTAGE CHANGE IN WATER LEVEL

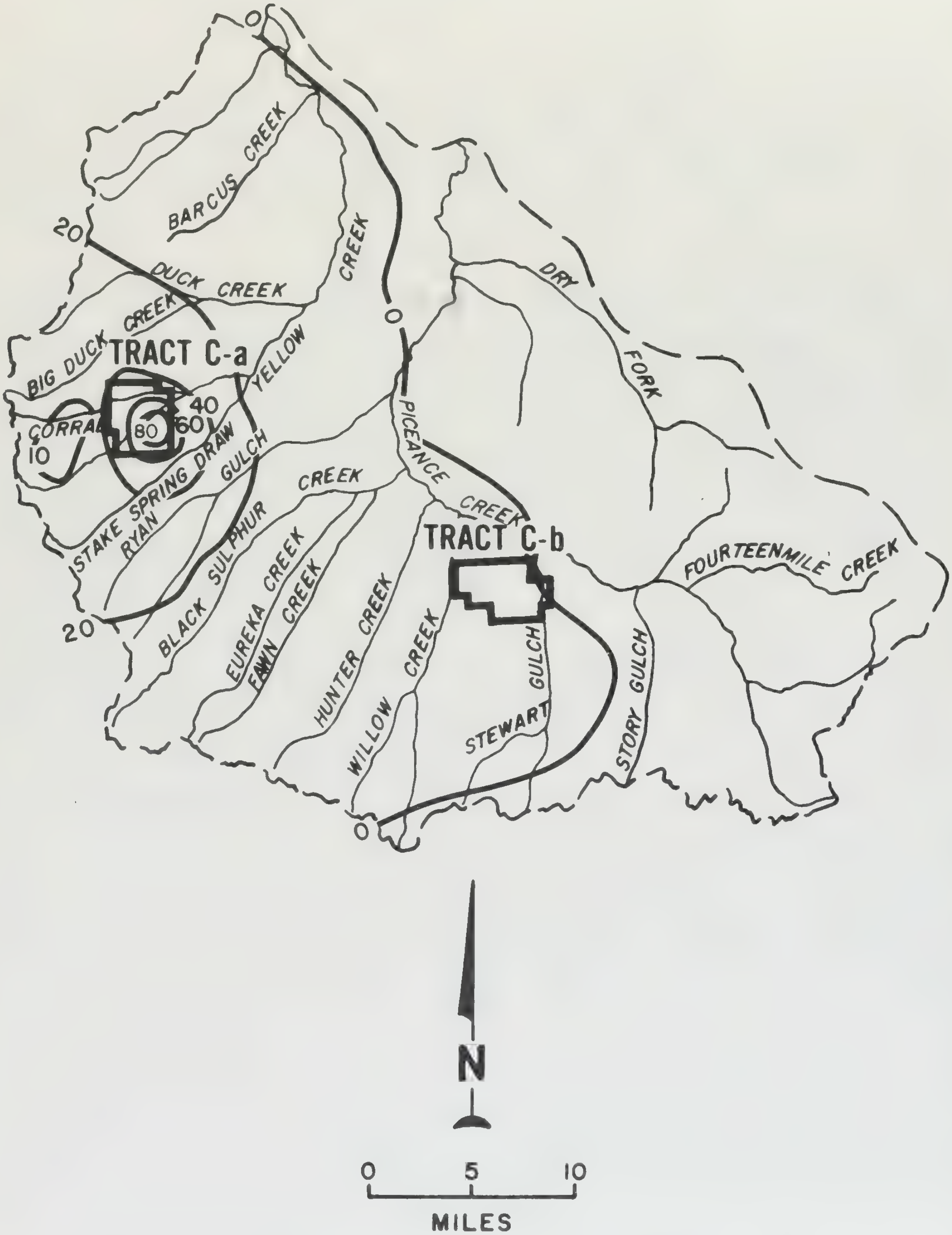

Figure 10-3-3

PHASE I LOWER AQUIFER FOOTAGE CHANGE IN WATER LEVEL

A limited number and variety of aquatic habitats occur on or near Tract C-a. These habitats receive virtually no human utilization, except that associated with occasional scientific investigations. In the following discussion of the potential impacts associated with RBOSP development, the various phases of the project are defined as Phase I--from 1977 through 1981; Transition Phase--from 1982 to 1985; Phase II--from 1985 on.

4.1 MINING

A. Phase I

1. Impact Assessment - During Phase I Stage 1, because the mine will be located in Dry Fork, where no aquatic habitats have been observed, and because there will be no direct discharges of seepage or rainfall from the pit into existing aquatic habitats, there will be no direct effects of mining on water quality or aquatic habitats. The indirect effects of mining activities on aquatic habitats and water quality include: those associated with mine dewatering, increased siltation (with some increase in turbidities and suspended solids) due to erosion and fugitive dust from construction activities and from increased use of unimproved roads; and increased or decreased flows resulting from water diversions. The increase in siltation will be greatly minimized by the implementation of the erosion control measures described in the water quality control plan (Section 9, Chapter 6).

The major indirect effect of mine development on aquatic ecosystems of the area will be a reduction in flow in certain spring-brooks and in Yellow Creek. As suggested in Section 3, Chapter 4, Hydrology, permanently flowing springs which are fed by the oil shale aquifers may be reduced to intermittent flow during Phase I of RBOSP development. Spring-brooks and marshy areas which will likely be affected during this phase include aquatic sampling Sites 3, 7 and 9 on Corral Gulch. As result of dewatering, these areas may contain water only during or following periods of precipitation and snowmelt. Stations 1, 2, 4, 8 and 13 will remain as the permanent spring-brook habitats and Station 14 will be the remaining pond habitat on or near Tract C-a. The area of permanent aquatic habitat which will be converted to an intermittent nature during the dewatering process includes approximately 1500 m^2 of spring-brook on Corral Gulch.

The flow reductions will affect the two major biotic communities of the spring-brooks, the periphyton and benthos. Periphyton communities of the tract stations were dominated by *Achnanthes minutissima*, *Navicula cryptocephala* and *Nitzschia denticula* throughout the year. There were no major differences between the intermittent and permanent area communities, and therefore decreases in flow are not likely to greatly affect the periphyton. Similarly, the benthic macroinvertebrates of the tract waters are presently well adapted to the intermittent conditions. Their short life cycles and certain resistant stages make them able to withstand droughts. However, the duration of dry periods will determine which of the species will survive. The present data do not indicate that the fauna of lower Yellow Creek or White River depend upon biotic input from tract area waters. Therefore, there should be little or no effect on downstream areas resulting from changes in periphyton and benthos due to dewatering of the spring-brooks.

The flow in Yellow Creek may also be considerably reduced during Phase I. In lower Yellow Creek (Stations 19 - 22), the reduction in flow will result in a reduction in the amount of available aquatic habitat. This reduction in the flow of Yellow Creek may be beneficial to the water quality of the White River near the mouth of Yellow Creek (Stations 28, 29) because of reduced salinities below the area of the confluence. The reduction in habitat will reduce the periphyton and benthos standing crops accordingly. However, there will probably be little change in the biotic community composition due to the reduced flows. Reductions in standing crops of periphyton and benthos will have little effect on the White River biota.

A second effect of mining operations on aquatic habitats on and near Tract C-a will be a temporary increase in silt loads and turbidity resulting from erosion and fugitive dust from construction activities and the use of unimproved roads. The aquatic habitat which will be most affected by such siltation will be the Corral Gulch spring-brook near aquatic sampling Station 9. Erosion from such activities will be minimized through use of procedures presented in Section 9, Chapter 6, Water Quality Control.

The increased silt loads will reduce periphyton production due to attached organisms being buried faster than they can grow. Silting will favor new algal taxa that are adapted to a depositing environment, especially the mobile pennate diatoms. Increased turbidity and silting will favor benthic macroinvertebrates that are adaptively protected, such as Caenis and Tricorythodes. The changes in periphyton and benthos will not significantly affect downstream areas. Silt loads and increased turbidity are not likely to affect the White River biota or water quality since there is normally no continuous flow from Corral Gulch to the White River.

During rains and periods of snowmelt, diversion of flood flow around the Dry Fork open pit to Corral Gulch will result in concentrated flows and increased velocities in Corral Gulch near the point of discharge. The effect of these intermittent high stream velocities will be to scour the substrates of those aquatic organisms not adapted to persist under such high velocities, such as nonburrowing invertebrates and weakly attached periphytic algae. This may temporarily reduce standing crops of periphyton and benthos. Periphytic algae will repopulate the area within days, but reductions in benthos will take longer to replace, and those species which can burrow into the hyporheic zone during floods may be favored.

2. Mitigative Procedures - The process of mine dewatering can potentially affect aquatic habitats by reducing rate of flow. Therefore water will be pumped from the upper aquifer to maintain surface water supplies. In addition, other specific measures which will be undertaken to avoid disturbance of aquatic habitats and to provide for temporary erosion control during construction

have been outlined in Section 9, Chapter 6, Water Quality Control, of this Detailed Development Plan. Control of fugitive dust from construction and road use will follow those procedures outlined in Section 9, Chapter 5, Air Quality Control. Since seepage and rainfall from the open pit will be collected in a sump and pumped to a lined lagoon outside the pit, no discharge will originate from the mine.

B. Transition Phase

1. Impact Assessment - During the period of transition from Phase I to Phase II, no direct effects of mining activites on aquatic habitats are anticipated. The potential indirect effects of mining activities include the alteration of aquatic habitats due to mine dewatering and an increase in siltation and turbidity due to construction activity.

The major aquatic habitat in Stake Springs Draw will be maintained in its existing state by pumping. Other existing aquatic habitats in Corral Gulch and Yellow Creek will be affected by mine dewatering but the rate at which this occurs is uncertain. Therefore the amount of permanent habitat which will be present during the Transition Phase cannot be estimated. During the Transition Phase, mine dewatering will continue to alter the permanent nature of the spring-brooks whose source is the oil shale aquifers.

As construction activity increases during the Transition Phase, siltation and turbidity will increase. The effects of such an increase will be transient and localized in nature since the aquatic habitat of this area of Corral Gulch will likely be ephemeral by that time.

Also during the Transition Phase, continued diversion of flood flows around the pit to Corral Gulch will result in intermittent high stream velocities near the point of discharge. The effects of these intermittent high stream velocities will be to scour the substrates near the discharge of those aquatic organisms not adapted to withstand the scouring.

2. Mitigative Procedures - The process of mine dewatering can potentially affect aquatic habitats by reducing rate of flow. Therefore, water will be pumped from the upper aquifer to maintain surface water supplies. Procedures designed to reduce the potential for increased siltation and turbidity (due to fugitive dust and erosion) in aquatic habitats on or near Tract C-a are outlined in Section 9, Chapter 5, Air Quality Control and Chapter 6, Water Quality Control. No discharge will originate from the mine since seepage and rainfall from the open pit will be collected in a sump and pumped to a lined lagoon outside the pit.

C. Phase II

1. Impact Assessment - During Phase II as the mining operation expands, any remaining aquatic habitats in the northwestern portion of Corral Gulch will be eliminated by expansion of the pit itself.

The mine dewatering operation during Phase II may reduce to an intermittent condition any remaining aquatic habitat (on or near Tract) whose source of water is an oil shale aquifer, with the exception of Stake Springs Draw. The flora and fauna of altered habitats will include an increased number of species able to survive prolonged periods of drought, as discussed in the previous sections.

During Phase II, the use of unimproved roads will result in increased silt loads and turbidity from fugitive dust. In addition, as construction of additional roads becomes necessary there will be an increase in silt loads and turbidity in nearby aquatic habitats, although these effects will be minimized through the use of erosion control procedures discussed in Section 9, Chapter 6, Water Quality Control.

Also during Phase II, continued diversion of flood waters around the pit into Corral Gulch will provide increased velocities during periods of precipitation or snowmelt, and these periods of high velocities will result in the scouring of aquatic organisms from the substrates, as discussed in the previous sections.

2. Mitigative Procedures - Some aquatic habitats in Corral Gulch will be eliminated by expansion of the pit itself. Others will be altered by the effects of mine dewatering. The loss of these habitats will be partially offset by the creation of a water control reservior which will provide additional aquatic habitat. The effects of mine dewatering will be partially offset by the diversion of flood flows into Corral Gulch. Procedures for control of fugitive dust are outlined in Section 9, Chapter 5, Air Quality Control, and procedures for avoiding disturbance of aquatic habitats during road construction and for controlling erosion during such construction are outlined in Section 9, Chapter 6, Water Quality Control. Procedures described in these two chapters will reduce the potential for increased siltation and turbidity in nearby aquatic habitats.

4.2 RETORT FEED PREPARATION

A. Phase I

1. Impact Assessment - No direct or indirect effects on aquatic habitats are anticipated for retort feed preparation because of the location of these activities at some distance north of existing aquatic habitats.

2. Mitigative Procedures - No mitigative procedures are planned.

B. Transition Phase

1. Impact Assessment - Because facilities for retort preparation are located at a considerable distance north of any existing aquatic habitats, no direct or indirect effects on aquatic habitats are anticipated.

2. Mitigative Procedures - No mitigative procedures are planned.

C. Phase II

1. Impact Assessment - No direct or indirect effects on aquatic habitats are anticipated for retort feed preparation because of the location of these activities at some distance north of existing aquatic habitats.

2. Mitigative Procedures - No mitigative procedures are planned.

4.3 PROCESSING

A. Phase I

1. Impact Assessment - Because the processing facilities will be located at a considerable distance to the north of any existing aquatic habitats, no impact on aquatic habitats is anticipated from construction of the facility during Phase I. Also, because water used in processing will be recirculated in a closed, zero discharge system and because storm drainage will be collected and utilized to moisturize processed shale; there will be no discharge of contaminated water to any existing aquatic habitat.

2. Mitigative Procedures - Description of the procedures designed to avoid the discharge of contaminated process water or storm drainage into existing aquatic habitats are presented in Section 8, Chapter 5, Water Supply and Control, and in Section 9, Chapter 6, Water Quality Control.

B. Transition Phase

1. Impact Assessment - Because the processing facilities will be located a considerable distance to the north of any existing aquatic habitats, no impact on aquatic habitats is anticipated from construction of additional processing facilities during the Transition Phase. In addition, since the operational processing system will include a closed, recirculating water system and since there will be no discharge of storm runoff to existing aquatic habitats, the processing operation should have no effect on existing aquatic habitats.

2. Mitigative Procedures - Descriptions of the procedures designed to avoid the discharge of contaminated process water or storm drainage into existing aquatic habitats are presented in Section 8, Chapter 5, Water Supply and Control, and in Section 9, Chapter 6, Water Quality Control.

4.4 PROCESSED SHALE AND OVERBURDEN DISPOSAL

A. Phase I

1. Impact Assessment - The potential effects on existing aquatic habitats of the disposal of processed shale and overburden include the flow of contaminated surface runoff into aquatic habitats, and intrusion of contaminated leachate from the piles into aquatic habitats. Investigations by Ward, Margheim, and Lof (1971) indicated that runoff (due to rainfall) from processed oil shale is likely to contain high concentrations of Na^+, Ca^{++}, Mg^{++}, and $SO_4^=$, but that concentrations of Ba^{++}, Cu^{++}, Cr^{+6}, F^-, Fe^{+++}, Pb^{++}, and Zn^{++} would be less than those allowable for human drinking water. Ward and Reinecke (1972) reported that the dissolved solids concentration in snowmelt water is increased significantly by contact with oil shale residue, but not as much as in runoff from rainfall. The aquatic habitats most likely affected by inflow of contaminated runoff or leachate would be those east of the tract in Corral Gulch (approximately 70 m^2 of aquatic habitat), Yellow Creek (intermittent) and the White River. Because the surface of processed shale will be compacted to form an essentially impermeable surface layer and the runoff from this surface will be diverted via lined ditches to lined holding ponds, there will be no direct discharge to aquatic habitats. In the unlikely event of an accidental discharge due to a dam failure or pond lining failure, the potential effects of such a discharge would depend upon the chemical composition of the discharge and the amount of dilution by the receiving water. The potential effects of the discharge of a highly saline leachate or runoff would range from no detectable effect to a marked decrease in the number of aquatic species and in their abundance. The communities most likely to reflect alterations in the aquatic ecosystem are the periphytic algae and the benthic macroinvertebrates, since the organisms belonging to those communities have limited mobility and are thus more susceptible to transient environmental changes.

2. Mitigative Procedures - The procedures which will be used to mitigate the effects of runoff and leachates on aquatic habitats are described in Section 8, Chapter 5, Water Supply and Control, and in Section 9, Chapter 6, Water Quality Control.

B. Transition Phase

1. Impact Assessment - As during Phase I, the potential effects on existing aquatic habitats include the flow of contaminated surface runoff from the processed shale or overburden piles into aquatic habitats. The habitats most likely affected by such leachates or runoff include those in Corral Gulch beginning at the eastern edge of the tract to its confluence with Yellow Creek (a total of approximately 70 m^2 of aquatic habitat), Yellow Creek (intermittent) and the White River. However, since processed shale will be compacted to form an impermeable surface layer and the runoff from this surface will be diverted via lined ditches to lined holding ponds, there will be no direct discharge to aquatic habitats. The potential effects of an accidental discharge of saline leachate or runoff due to a dam or pond lining failure should range from an undetectable effect to a marked decrease in the number of abundance of aquatic species. The communities most likely to reflect subtle alterations in the aquatic ecosystem are the periphytic algae and the benthic macroinvertebrates, since the organisms which belong to those communities have limited mobility and are therefore more susceptible to transient environmental changes.

2. Mitigative Procedures - Descriptions of the procedures to be used to divert and contain runoff and leachate from processed shale and overburden piles are presented in Section 8, Chapter 5, Water Supply and Control, and Section 9, Chapter 6, Water Quality Control.

C. Phase II

1. Impact Assessment - The potential effects on existing aquatic habitats are the same as described for both Phase I and the Transition Phase.

2. Mitigative Procedures - The procedures which will be used to mitigate the effects of runoff and leachates on aquatic habitats are described in Section 8, Chapter 5, Water Supply and Control, and in Section 9, Chapter 6, Water Quality Control.

4.5 ANCILLARY FACILITIES

A. Phase I

1. Impact Assessment - During Phase I, the direct effects on aquatic habitats will include a temporary increase in siltation and turbidity associated with corridor and building construction, inundation of approximately 70 m^2 of aquatic habitat by creation of a water control reservoir in Corral Gulch east of the tract and potential inflow of oils via surface runoff from roadways. Increase in siltation will be minimal because of implementation of the erosion control measures as set forth in the water quality control plan (Section 9, Chapter 6).

Any effects of increased erosion and siltation from construction of ancillary facilities will occur mainly in Corral Gulch (near aquatic Stations 12 - 14) and will include approximately 1600 m^2 of aquatic habitat. The effects of this limited siltation will be negligible on the aquatic biota since periods of high turbidities and suspended solids concentrations are a natural phenomenon in these areas and the biota which occurs there can tolerate such limited disturbances.

The inundation of approximately 70 m^2 of spring-brook habitat in Corral Gulch will result in a shift to a pond habitat. This pond (water control reservoir) will be larger (1×10^6 m^2) than any similar habitat on or near Tract C-a and it will develop an aquatic flora and fauna characteristic of such alkaline ponds. The potential effects of oily surface runoff from road surfaces are expected to be small since the area most likely to be affected is near the confluence of Corral Gulch, Stake Springs Draw and Yellow Creek (near Rio Blanco County Road 24) where aquatic habitats are intermittent in nature. Traffic on unpaved service roads near aquatic habitats (such as the Ryan Gulch) is expected to be very light (Section 8, Chapter 4, Transportation) and thus the amount of oily surface runoff should be small.

2. Mitigative Procedures - Specific procedures designed to minimize the potential for erosion and fugitive dust are outlined in Section 9,

Chapter 6, Water Quality Control, and in Section 9, Chapter 5, Air Quality Control. Loss of approximately 70 m^2 of spring-brook habitat by inundation for the water control reservoir will be mitigated by the formation of approximately 1×10^6 m^2 of pond habitat. The creation of this new aquatic habitat will also greatly offset the effects of dewatering on other aquatic habitats.

B. Transition Phase

1. Impact Assessment - During the transition period between Phase I and Phase II, many of the ancillary facilities will be relocated. Many of these facilities will be relocated to the east of the truck shop (and thus to the north of aquatic habitats in Corral Gulch). The effects of this relocation could include increased turbidity and siltation in existing aquatic habitats due to erosion and fugitive dust resulting from construction activities, and a potential increase in oily surface runoff due to increased traffic on roads in Corral Gulch.

Because the aquatic habitats in Corral Gulch are expected to be intermittent (due to mine dewatering) during the Transition Phase and because of erosion control measures, the effects of increased turbidity and siltation on aquatic habitats will be transient and of limited magnitude. Oily surface runoff is not expected to be a problem.

2. Mitigative Procedures - Specific mitigative procedures designed to minimize the potential for erosion and fugitive dust are outlined in Section 9, Chapter 6, Water Quality Control and Chapter 5, Air Quality Control.

C. Phase II

1. Impact Assessment - During Phase II, construction of additional corridors could result in increased siltation and turbidity in existing aquatic habitats near such construction. (This should be largely prevented by erosion prevention measures.) In addition, it is anticipated that certain ancillary facilities will be moved as the mine expands. Construction

activities related to this movement of facilities could also result in a limited increase in siltation and turbidity in nearby aquatic habitats. Oily surface runoff may affect the intermittent aquatic habitat but the extent of the effect should be very limited.

2. Mitigative Procedures - Specific procedures intended to minimize erosion and fugitive dust are discussed in Section 9, Chapter 6, Water Quality Control and in Chapter 5, Air Quality Control. No specific procedures are anticipated to control surface runoff from access, haul or service roads.

The objective of this chapter is to define, as present knowledge permits, the biological impacts of the activities planned for the development of the oil shale resources at Tract C-a prior to implementation of the Fish and Wildlife Management Plan (Section 9, Chapter 11). In addition, mitigative procedures will be suggested to reduce the severity and/or longevity of these impacts. In general, this assessment has identified the severity of impacts of oil shale mining on a local (Tract C-a) and immediate vicinity basis. The conclusions of this chapter are that local oil shale-related impacts could be severe (on a worst-case basis) due to physical destruction of the habitat (food, water, and shelter), increased human presence, mine dewatering, and process emissions. However, mitigative action should minimize their environmental effect. Tract C-a operations viewed from a regional prospective should have a negligible biological impact on the Piceance Basin.

Impact assessment emphasis will be given to "important" species. Importance reflects a human value judgement which is not easily quantified and which may be made in several contexts. According to the Nuclear Regulatory Commission guidelines (1975), the importance of a species may be a function of its recreational value, its economic influences in relation to agriculture, its status as a rare or endangered species, its aesthetic qualities (all of which reflect a culturally-shaped view of the species), its role in the energy or nutrient webs of ecosystems, or its function in controlling the dynamics of other populations (both of which reflect biologically determined values). In some cases, application of these guidelines is more appropriate for a broader category than a single species. Thus, vegetation may be treated as important by vegetation type, as a soil stabilizer, or lumped under the category of "producer" organisms. Similarly, invertebrates may be grouped by trophic level affinities or by special ecological function (e.g., pollinators). Because there is seldom a sharp cutoff demarcation between important and "non-important" species or groups, the discussions must necessarily exclude some organisms or environmental factors.

Birds are an example of the ways that importance may be assigned. Certain recreationally important species of waterfowl and gamebirds occur in the study area. Waterfowl and other species characteristic of shoreline habitat are also attributed a particular kind of importance as components of communities which are locally rare or unique in the study area (riparian communities). Most raptor species encountered in the region are considered important both because of their aesthetic value and because of their role as top carnivores in local food webs. The peregrine falcon has been classified as an endangered species.

Using these criteria supported by the derivation of bird species importance values calculated from baseline data (Section 3, Chapter 7.2; Table 3-7-10), "biological importance" was assigned to certain bird species inhabiting the Tract C-a area. Of the 129 bird species observed within the study area, 23 were designated as important. These species, their habitats, and impacts to their populations are discussed in various sections of this chapter.

In the case of small mammals, somewhat different criteria were used. Since no really unique or rare species of small mammals are found in the areas to be disturbed, the least chipmunk and deer mouse were selected as important species because of their abundance and ubiquity in local vegetation types. Cottontail rabbits, deer, feral horses, and cattle are also discussed as important species; cottontails, deer, and cattle for economic reasons, and feral horses for ecological and aesthetic reasons.

Special consideration is given in the following impact assessment to edge or ecotonal habitats (zones of transition between different vegetation types). According to Odum (1959), an ecotone contains many of the organisms of each of the overlapping communities in addition to those organisms which are characteristic of and often restricted to the ecotone. Thus, losses of ecotonal areas are particularly important because of the high species diversity generally represented in edges. Within this section, losses of edge habitat are given in linear measure (m, mi) since the width (or depth) of ecotones varies widely from very sharp edges of only a few meters to broad transitional zones between vegetation types.

Wherever it is feasible to estimate population densities of important species, these estimates will be used to give an approximate figure for habitat-carrying capacity losses due to a given area disturbance. Population estimates have been computed using baseline data (Section 3, Chapter 7.2) and a few reliable literature sources. The population density estimation methods tend to have numerous assumptions (of variable validity) which require that their application be viewed with caution. Nevertheless, these are the best available site-specific density estimates and the judgements derived from these are assumed to be as good as can be made on the current information base.

Within the specific activity and phase of the operation, impacts are assessed, as much as is practicable, in a trophic level order beginning with soils as the primary nutrient reservoir and continuing through producers, primary consumers (herbivores), and higher order consumers. Occasionally a deviation from this ordered approach is necessary to maintain continuity of discussion of a particular set of interactive impacts, but the general approach is to mention the repercussions through the food chain from the source or primarily impacted level.

In several instances, biological impacts are assessed for an activity even where a control plan has been presented in Section 9. This has been done in cases where, due to the unpredictability of nature or uncertainties of design, it cannot be reasonably certain that all impacts can be avoided. In such cases, it should be emphasized that safety measures are planned to handle any presently unforeseeable events.

As the terrestrial baseline studies were conducted within an area extending 5 miles from the tract boundary, impact assessment will be restricted to this "study area". By this method, the immediate, localized impact of any activity can be viewed in terms of its effects on local ecosystems.

Mitigation of impacts entails minimizing the severity of impacts by rehabilitation of disturbed areas and by habitat enhancement (compensation for lost habitat). Habitat enhancement is addressed in Section 9, Chapter 11. Rehabilitation of disturbed areas is discussed in Section 9, Chapter 8, and these plans are referenced in the mitigative procedures section following each impact assessment section.

Mitigative procedures are presented following the discussion of each type of impact (e.g., area disturbance, noise, dust, etc.). For some types of impacts there may be little or nothing that can be done in mitigation. For example, mitigation of a permanent (or long-term) area disturbance may not be feasible beyond exercising caution in avoiding the initial disturbance of more area than is absolutely necessary.

Because the understanding of natural systems is incomplete, the following impact assessment and mitigative procedures are presented as the best available, based on site-specific biological data and technical details of the proposed development. The monitoring program described in Section 11, Chapter 4 is designed to: verify the accuracy of impact assessment present here, as well as the adequate functioning of mitigation plans; to detect unanticipated impacts; and to provide an information base for updating environmental control, rehabilitation and wildlife management plans.

The assessment of all RBOSP oil shale development activities is presented in terms of phases. Phase I (1977 to 1981) includes initial development of the open pit mine through operation of the second retort. The Transition Phase (1982 to 1985) covers the period of continued operation of the second retort, accompanied by the added disturbance of construction of a fully operational commercial-sized plant. Phase II (1986 to 2015) covers the period of impact beginning with the initial operation of the commercial facilities through the life of the project.

5.1 MINING

A. Phase I

1. Impact Assessment - Development of the open pit mine during Phase I (1977 to 1981) will entail disturbance of approximately 40 ha (100 A) covered by mixed brush (75%), sagebrush (20%), and pinyon-juniper (5%) vegetation types. Approximately 1.1 km (0.7 mi) of sagebrush/mixed brush and 0.3 km (0.2 mi) of sagebrush/pinyon-juniper edge habitat will be removed during pit development.

In addition, approximately 6.5 ha (16 A) of vegetation (62% pinyon-juniper and 37% sagebrush) will be disturbed by construction of the ore conveyor. Vegetation removal may increase the soil erosion potential of stripped areas, possibly increasing runoff rates and volume and runoff sediment loading. After vegetation clearing, some reduction in lateral nutrient flow in the immediate vicinity is expected. The exact degree to which this reduction in nutrient flow will affect downstream terrestrial ecosystems cannot presently be predicted.

Herbivores supported by the vegetation removed include:

- small mammals in the disturbed area, especially rodents and lagomorphs
- local species of birds
- the ungulates utilizing the area (cattle, horses, and deer)
- invertebrates, including species both harmful and beneficial to host plants

As shown in Section 3, Ch. 7.2, the most numerous small mammals in the area are the least chipmunk and the deer mouse. Because of their abundance in the vegetation types to be disturbed, these two species are used as examples of small mammal habitat-carrying capacity losses. Their abundance within the study area also makes these species important locally, both as herbivores and as prey species for mammalian and avian predators. Estimates of least chipmunk population densities ranged from 2.0/ha (2.0 individuals per hectare) to 4.4/ha (0.8 to 1.8/A), with a mean of 3.2/ha (1.3/A) for the mixed brush vegetation type; from 1.0 to 12.6/ha (0.4 to 5.1/A), with a mean (over both sampling grids) of 4.2/ha (1.7/A) for the pinyon-juniper vegetation type; and from 2.2 to 6.9/ha (0.9 to 2.8/A), with a mean of 4.0/ha (1.6/A) for the sagebrush vegetation type over a period of 1 year. Similarly, deer mouse population density estimates ranged from 1.0 to 7.7/ha (0.4 to 3.1/A), with a mean of 3.7/ha (1.5/A) for the mixed brush vegetation type; from 1.0 to 8.4/ha (0.4 to 3.4/A) (over both sampling grids), with a mean of 3.2/ha (1.3/A) for the pinyon-juniper vegetation type; and from 1.2 to 3.2/ha (0.5 to 1.3/A), with a mean of 2.0/ha (0.8/A) for the sagebrush vegetation type (October 1974 to October 1975).

The high variability of rodent populations shown in the above estimates makes it difficult to assess impacts in terms of a normal or average density (excluding cyclic highs and lows). Therefore, impacts to rodent populations will be assessed in ranges of the lowest known population density to the highest. Thus, disturbance of mixed brush during Phase I mining will eliminate habitat which could support 60 to 132 least chipmunks (30 ha x 2.0 chipmunks/ha low; 30 ha x 4.4 chipmunks/ha high) and 30 to 231 deer mice. Similarly, habitat for 18 to 55 least chipmunks and 10 to 26 deer mice will be eliminated by sagebrush disturbance and 2 to 25 least chipmunks and 2 to 17 deer mice habitat will be removed along with the pinyon-juniper disturbance. In addition to these two rodents, this habitat removal will also result in a loss of habitat that could support ground squirrels, shrews, voles, and other mice. These small mammal species provide food roughly in proportion to their abundance for several species of carnivores including long- and short-tailed weasels, coyotes, and raptorial birds. Any loss in small mammal habitat will result in a reduction in available food for their predators. Because of the wide area available as hunting habitat for the predators, it is difficult to assess how removal of a portion of their hunting range may affect them. However, if predators are food-limited, a reduction in predator numbers proportionate to the reduction in their food supply would be expected (Hairston et al., 1960). As long as the disturbance remains, a portion of the area's harvestable surplus or prey animals will no longer be available to predators.

However, if some other factor (e.g., nesting habitat or shelter) presently limits the abundance of a predator species locally, a reduction in their numbers would not be expected from mine area disturbance unless the area disturbed held some portion of the region's limiting resource. There is no evidence at present that the area to be disturbed by mining contains unique and limiting resources for any local mammalian or avian predators.

The impact of mine development on local small mammal populations will be immediate. Escape and re-establishment in adjacent areas is not likely for the following reasons:

- Most of the small mammal species are both secretive and restricted in their normal range of movement -- they will tend to hide rather than flee.

- Areas adjacent to the disturbed area may already be fully occupied; immigrants would be at a severe competitive disadvantage (Pianka, 1974).
- Immigrants to an unfamiliar area will be more susceptible to predation and/or death by exposure to the elements.

Cottontails (Sylvilagus sp.) are much more mobile than the smaller small mammals but, because of their nocturnal (or crepuscular) and burrowing habits, few would escape the disturbance. Currently, cottontail supplies in Colorado exceed the demand (Colorado Division of Wildlife, 1974), but future increases in human population may increase the value of this small game species. Current local rabbit hunting is low because of the relative remoteness of the area and possibly because cottontail populations regionally appear to be at a cyclic low.

Rabbits and hares in the area serve as a food source for mammalian and avian predators. Losses of rabbit habitat may affect local predator populations in proportion to decreases in their food supply. According to Shepherd (1965), most of the better rabbit habitats of Colorado support a possible cottontail density of 0.6 to 0.8/ha (150 to 200/sq mi) excluding cyclic highs and lows. Baker and McKean (1971) feel this figure is applicable to the Piceance Basin. Using these numbers as a reasonable estimate of normal rabbit density, the mine development would remove habitat which could support approximately 25 to 30 cottontails.

Birds, like small mammals, are dependent upon vegetation for food, nest locations, and, to some extent, their water supply. Removal of the vegetation in the pit opening constitutes removal of productive avian habitat and forces birds to disperse. The ability to disperse into surrounding areas is dependent on the species displaced and the carrying capacity of the adjacent, non-disturbed communities for that species. If areas adjacent to construction activities are presently at carrying capacity, the displaced birds may not be capable of re-establishing themselves and, thus, could be removed from the local breeding populations.

The most important avian species in the area to be disturbed by Phase I open pit mining include the mountain bluebird, dark-eyed junco, and blue-gray gnatcatcher in mixed brush habitat; a number of different species including the scrub jay, bushtit, mountain bluebird, dark-eyed junco, and others in the pinyon-juniper habitat; the mountain bluebird, vesper, chipping, and sage sparrows, yellow-rumped warbler, and horned lark in the sagebrush habitat.

If the amount of disturbed area in a given vegetation type is multiplied by the number of birds per unit area for selected important species (as calculated from strip census data; Section 3, Chapter 7.2), then the number of individuals of each species displaced by mine construction can be calculated. For example, vegetation clearing during Phase I mining will remove habitat that could support 17 to 18 green-tailed towhees in lowland mixed brush vegetation, 1 to 5 mountain chickadees in pinyon-juniper, and 2 to 5 horned larks in lowland sagebrush.

Only one inactive raptor nest has been located in the vicinity of the mine site. However, the area could potentially support nesting Cooper's hawks, kestrels, red-tailed hawks, and great horned owls. All of these species have been recorded within at least one of the three habitat types during the summer months. Although the majority of raptor observations over all seasons were made east of Tract C-a (Section 3, Chapter 7.2), the tract is within the normal hunting range of these raptors, and the planned disturbance may remove a portion of the prey populations supporting summer breeding raptors and wintering raptor species found in the study area such as golden eagles, rough-legged hawks, marsh hawks, and ravens.

The pit development will be subtracted from the total range available to support local feral horses, deer, and domestic cattle. Domestic cattle productivity losses can be calculated on the basis of current stocking rates and are not large relative to total grazing for cattle in the area. Browse conditions on the study area were overwhelmingly in the "good" condition class. A large portion of the range exhibited a decrease in condition. However, present data precludes a definitive assessment of impacts on range and browse conditions and the species utilizing such forage.

Mule deer usage of the area for forage and cover is lowest in summer and higher during fall, winter, and spring. The specific importance of the area to be disturbed by the mine is difficult to assess accurately in terms of deer productivity losses because of the mobile and dispersed nature of the local mule deer population. Deer migrate through the area in a wide pattern, and mining activities are not expected to affect migratory behavior. Deer, for the most part, will learn to avoid the pit area during migration or winter usage of the area. Deer displaced from the impact area will utilize adjacent areas if quality winter range is available. Before this displacement pattern becomes the new norm, however, an increased human-deer interference such as vehicle-deer collisions is expected during the spring and fall periods of maximum mule deer movement.

Area disturbance in the Phase I mining operation will also affect invertebrate populations. Although seemingly insignificant, invertebrate populations are an important primary consumer group and also function in the breakup and decay of plant litter (a critical point in nutrient transfer in semi-arid regions). Populations of relatively non-mobile invertebrates in the disturbed area will be destroyed. These include virtually all the soil fauna including the abundant ticks, mites, springtails, and ants. In addition, baseline data (Section 3, Chapter 8.2) indicate that several groups of relatively non-mobile predators (spiders, pseudoscorpions) are the most numerous predators in the litter (ground-dwelling fauna) and other strata. Thus, mining activities will eliminate a portion of the local invertebrate predator population.

Species with flight capabilities will be able to emigrate to areas adjacent to the disturbed area. This may result in a temporary increase in damage to host plants in these adjacent areas until ecosystem equilibrium is attained. The dependence of wasps and especially wild bees on a home nest makes their successful escape from the disturbance less likely than for other flying species. Wild bees are an important pollinator group in the area, and the removal of one or more colonies could temporarily decrease successful pollination of wildflowers peripheral to the disturbed areas. Wild bee nests are found most frequently in the pinyon-juniper vegetation type, probably because of available nesting sites in dead wood, so destruction of areas of pinyon-juniper more seriously affects bees than disturbance of other vegetation types. While dead wood provides nesting sites for wild bees, it also provides oviposition sites for woodboring insects. Rivnay (1964) reported that in several cases, an increase in available dead wood resulted in an increase in borer populations from low numbers to levels at which economic injury to tree crops may occur. Similarly, carpenter ant population increases may result (Sanders, 1970) if more dead wood is available by discarding cleared vegetation adjacent to the cleared areas.

Some insectivorous birds may benefit temporarily by gleaning invertebrates disturbed during surface stripping. Reptile populations outside of the area of disturbance will also benefit from increased prey. In both cases, the effect will be restricted to the immediate surrounding area of disturbance.

Accurate assessment of potential population decreases of local avian and mammalian insectivores due to area disturbance of mining is not feasible due largely to their wider ranging habits. Any reduction in the area available to support these species may be expected to influence the carrying capactiy of the whole area if it is assumed that these predators are food limited. Thus, a reduction in predator populations may be expected which is proportionate to the relative amount of prey habitat lost.

Mine operations effects besides area disturbance (clearing) include:

- Noise -- construction equipment, blasting, conveyors, etc.
- Dust -- construction equipment, blasting, conveyors, etc.
- Mine dewatering
- Human presence

Noise can have several effects on wildlife, including hearing loss or aberrant behavior at high noise intensities. The most common responses of animals to noise are avoidance and accomodation (i.e., they either leave the area or get used to and ignore the noise). Except at extreme levels, most of the more secretive and smaller animals could coexist with the noise source treating it as background noise. Other animals, especially those which rely most on auditory cues for orientation and those using vocal communication (i.e., songbirds) will avoid the vicinity of a noise source, moving away until the noise level drops to an acceptable background level for that species.

The nature of the source of a noise may influence the response of fauna to it. Abrupt and intermittent noises (e.g., blasting, haul trucks) are less likely to produce accommodation than are more steady, continuous noises (e.g., conveyor).

Major pieces of mobile equipment (including trucks and loaders) are expected to produce noise levels of 85 to 95 dbA measured at a 15-m (50-ft) distance. Most of the sources of noise from the mining operation will be isolated in the pit (crusher, blasting, some haul trucks, and part of conveyor) or will be along a disturbance route (roads). Thus, a narrow band along noise routes or around stationary sources in otherwise undisturbed areas may be expected where animals may move away from intolerably high noise levels. Avoidance of high noise level areas is expected to attenuate from the noise source and should not persist (except for extremely avoidance-prone animals like feral horses) beyond a few hundred meters.

Dust produced by the mining operations can be harmful in several ways to adjacent flora and fauna. In extreme cases, photosynthetic activity can be inhibited by dust buildup on leaf surfaces during dry periods. Ingestion of dust-covered leaves can increase tooth wear in deer (Einarsen, 1956). Because tooth deterioration is an important contributor to death and disease, dusting of large areas of prime deer range could be detrimental. Bees may have their pollen-gathering capability diminished by dust on body hairs since the hairs have an important role as a pollen-collection organ (Pradhan, 1959). Particles less than 5μ may interfere with proper function of the tracheal system of bees and other insects by clogging surface pores (large particles are prevented from reaching the body surface by the hairs). This would reduce oxygen intake of flying insects which need large quantities of oxygen for flight (Connell and Jones, 1952). High airborne particulate matter concentrations may favor aphid or other herbivorous invertebrate population increases by interferring with the life cycle of parasitic wasps which aid in controlling invertebrate herbivore populations (Hillmann, 1972). Dessication is a primary factor in regulation of Collembola (springtail) populations (Ford, 1937; Christiansen, 1964; Section 3, Chapter 7.2). Dust accumulation on ground and leaf surfaces may contribute to absorption of moisture, thereby reducing the desirability of the habitat for Collembola, an important litter invertebrate group.

Probably the most serious danger of dust to exposed fauna is its harmful effect on mucous membranes. Chronic eye irritation by larger particles is possible from a cumulative abrasive action which tears and/or a nictitating membrane are not able to control completely. Immediate and long-term pulmonary function changes may accompany exposure to dust (Tashio et al., 1973; Takemoto et al., 1974; McArn et al., 1974) with heavier dust exposure resulting in more pronounced effects. These changes may result from coating of lung air sac (alveolar) surfaces -- reducing total gas exchange surface area.

Projections of dust emissions from various sources and dust control measures explained in Section 9, Chapter 5 suggest that if all goes as planned, dust levels can be maintained at a low enough level to avoid many of the possible effects outlined above. Initial clearing of the mine site requires special attention to dust control to prevent excessive fugitive dust. The greatest dust problem from mine development after initial surface clearing is expected along the haul roads, since the conveyor is enclosed (and mechanically dust-controlled) and the mining dust production will increasingly settle in the pit itself as the pit deepens.

Variable weather conditions and traffic loads can make road surface drying rates unpredictable. Therefore, some inefficiency is inherent in a road watering program wherein sometimes watering is a little too late for optimum dust control. Some leaf surface coating in plants, causing reduced photosynthesis and damage to respiratory systems in animals, is expected along roadways. Just as with noise (though in a different fashion), this harmful effect is attenuated fairly rapidly from the source (road).

Recent dewatering analyses studies suggest that the water tables in portions of the Piceance Creek basin may be affected by Tract C-a mine dewatering. This lowering of the water tables may affect flow of seeps and springs which are connected to the deep aquifers involved, thereby reducing the amount of available surface water.

As more people enter this area to take part in mining construction activities, additional effects upon local fauna will result from increased human-wildlife encounters such as vehicle collisions and nest disturbance. The greatest effects will be exerted on species such as feral horses which are human-shy. It is possible that feral horse avoidance of noise sources is more an avoidance of human presence than of decibel levels alone. Such sensitive species will generally tend to move away from the center of human activity, thus lessening the impact of human encounters. Vehicle-deer collisions may affect local deer herds. However, present knowledge of Tract C-a deer prevents a definite conclusion of "road kill" impacts at this time.

2. Mitigative Procedures - The impacts of area disturbance can only be mitigated to the extent that the total area disturbed is minimized, that wildlife enhancement procedures increase productivity of adjacent areas, or that disturbed areas are successfully revegetated. To accomplish these ends, care can be taken to avoid, wherever feasible, the movement of equipment outside of the planned boundaries of the mine pit. In addition, surface exposure for pit development can be paced as much as is possible so that habitat is available for wildlife utilization for a maximum feasible length of time. That is, no more surface will be cleared than is to be used before the next breeding/ growing season.

Excess peripheral disturbance will be revegetated as soon as feasible. Rehabilitation efforts can be made along haul roads, along the conveyor route, and around the mine pit perimeter (Section 9, Chapter 8). Aside from this mitigative (or recovery) effort, the main area of disturbance, the pit itself, will be a total habitat removal throughout and beyond Phase I. The noise and dust abatement and control plans presented in Section 9, Chapters 4 and 5 should keep these factors held to a minimum.

If mine dewatering results in large downward fluctuation in water tables, RBOSP will augment these losses as required.

B. Transition Phase

1. Impact Assessment - During the Transition Phase (1982 to 1985) of mining, the total area disturbance will increase to approximately 57 ha (140 A) formerly occupied by mixed brush (70%), sagebrush (28%), and pinyon-juniper (2%). Edge losses will total approximately 3.4 km (2.1 mi) of sagebrush/mixed brush (93%) and 0.2 km (0.1 mi) of pinyon-juniper/sagebrush (7%) transitions. The conveyor system will not take any additional area.

The cumulative impact of mining operations through the Transition Phase will occur in the same categories as discussed for Phase I but will be greater proportionate to the increased area of disturbance. Mine dewatering effects on surface water supplies will become more pronounced during this phase.

In a sense there will be more kinds of effects during this phase than any other because of greater overlap between major construction and operation activities than at any other time during the operation.

2. Mitigative Procedures - The same mitigative procedures for Phase I apply to the Transition Phase development. Revegetation efforts on areas temporarily disturbed during Phase I mine development (mine perimeter, conveyor corridor, etc.) should be essentially complete by the Transition Phase.

C. Phase II

1. Impact Assessment - Cumulative vegetation removal through Phase II (1986 to 2015) of mine development will be approximately 312 ha (770 A) formerly occupied by mixed brush (65%), sagebrush (25%), pinyon-juniper (7%), and shadscale (3%). Total edge habitat removed will be approximately 7.2 km (4.5 mi) (50% mixed brush/sagebrush, 37% mixed brush/pinyon-juniper, 8% sagebrush/shadscale, and 5% sagebrush/pinyon-juniper).

The potential for impacts in this phase of the operation is proportional to the increase in its scope. Thus, with all systems running at peak rate, impacts of area disturbance, dust, noise, and mine dewatering will be at a maximum.

2. Mitigative Procedures - The mitigative procedures for Phase I and the Transition Phase will serve for Phase II as well. By this time revegetation of all temporarily disturbed areas (except recently disturbed mine periphery) will have been completed, resulting in a partial recovery of some of the carrying capacity lost when these areas were disturbed.

5.2 RETORT FEED PREPARATION

A. Phase I

1. Impact Assessment - Because this operation is completely enclosed within the plant site, the area disturbed by the machinery is included under Section 10, Chapter 5.3. This operation has a potential for production of noise and dust. Both of these are expected to have only very slight impact on local wildlife. There are two primary reasons for this:

- The operation of conveyors and crushers takes place inside a much larger area of disturbance where close wildlife approach to the machinery is unlikely.
- Control measures discussed in Sections 9, Chapters 4 and 5 suggest that overall dust emissions will be very low from this machinery, and that noise propagation beyond the plant site will be at low decibel levels.

2. Mitigative Procedures - The procedures outlined in Sections 9, Chapters 4 and 5 should be adequate for minimizing the effects of retort feed preparation. The operation of the control facilities will be monitored to assure that projected noise and dust emission levels are not substantially exceeded during operation of the equipment.

B. Transition Phase

1. Impact Assessment - The rate of material handling will increase during this period, with a concomitant increase in the potential for dust emissions.

It is expected that these emissions will remain below the Colorado weight rate emissions limit and much of the dust that is emitted will settle on disturbed areas, either within the plant site or further downwind.

2. Mitigative Procedures - Planned dust and noise control procedures described in Section 9, Chapter 5 will continue. Continued equipment maintenance will insure that planned control efficiencies are maintained.

C. Phase II

1. Impact Assessment - Potential for dust and noise will reach a maximum in Phase II as material handling peaks. With planned control procedures (Section 9, Chapter 5), neither dust nor noise from this source are expected to have a substantial impact on local wildlife.

2. Mitigative Procedures - A continuation of the procedures of Phase I and the Transition Phase will, with appropriately increased application, minimize the effects of retort feed preparation during Phase II.

5.3 PROCESSING

A. Phase I

1. Impact Assessment - The effects of processing facility operations upon local ecosystems may be categorized into two types:

- Removal of vegetation during plant site preparation and facilities construction (area disturbance)
- Water and windborne processing effluents -- including gaseous and particulate stack emissions and cooling tower drift

A total of approximately 46 ha (115 A) of vegetation will be removed during Phase I (1977 to 1981) for the plant site (59% pinyon-juniper and 41% sagebrush). Approximately 2.1 km (1.3 mi) of sagebrush/pinyon-juniper edge habitat will also be removed. This area disturbance estimate includes all the activities within the plant site boundaries including retorts, conveyors, crushers, administrative buildings, parking lots, etc.

Clearing of vegetation cover may increase wind and water erosion and elevate sediment loads in water courses draining the disturbed area.

Small mammals will be affected in a manner similar to that discussed in Section 10, Chapter 5.1. Removal of habitat that could support 28 to 350 least chipmunks associated with pinyon-juniper and 42 to 133 least chipmunks associated with sagebrush will be affected along with removal of habitat that could support approximately 28 to 233 and 23 to 62 deer mice in pinyon-juniper and sagebrush, respectively. Based on the assumption presented in Section 10, Chapter 5.1, habitat which could support approximately 28 to 36 cottontails will be eliminated during Phase I clearing. Lesser amounts of habitat for other small mammals will also be eliminated during these activities. The effects of habitat removal on dependent predators will be small relative to the total available area.

Effects on birds will also be small relative to the study area due to the wide distribution of the pinyon-juniper and sagebrush vegetation types. The most important avian species in the area to be disturbed by Phase I processing and land clearing operations include the bushtit, horned lark, black-billed magpie, mountain chickadee, gray and solitary vireos, black-throated gray warbler, and chipping sparrow in the pinyon-juniper; and the vesper sparrow, Brewer's sparrow, sage sparrow, yellow-rumped warbler, mountain bluebird, and horned lark in the sagebrush habitat. It is estimated that clearing of 28 ha (69 A) of pinyon-juniper could result, for example, in losses of habitat for 22 to 33 black-throated gray warblers and 6 to 44 mountain chickadees; the clearing of 19 ha (47 A) of sagebrush may result in losses of habitat for 2 to 8 mountain bluebirds, 6 to 23 vesper sparrows, and 14 to 40 Brewer's sparrows.

The processing facility and the associated human activity will further contribute to the concentration of the native ungulates to areas away from Tract C-a (primarily north, west, and south), thereby increasing interspecific and intraspecific competition for food among this group.

The effects of the area disturbance of Phase I plant site preparation will be exactly analagous to those discussed in Section 10, Chapter 5.1. The ratios and numbers of individuals of the various invertebrate groups disturbed will vary proportionate to the change in types and quantities of vegetation disturbed. The sagebrush lizards and short-horned lizards residing in the area disturbed will be extirpated along with their insect prey. Both these losses are minute in comparison to existing populations in the surrounding available habitats.

The dust and noise of construction and operation of the Phase I processing facility will have effects varying from those discussed in Section 10, Chapter 5.1 only to the extent that processing facility construction and operation noise and dust production differ quantitatively from those of mining operations. No information is currently available concerning the level of noise production during processing.

The greatest potential impact of the oil shale processing operation is the deleterious effects of plant emissions on the local flora and fauna. As the first retort goes into operation, various products, by-products, and effluents will be produced which, if deposited on the local environment in sufficient quantities, could result in local environmental degradation.

Liquid products and wastes stored on site, transported through the product pipeline, or disposed of off-site may be subject to accidental spills which could escape into either local water courses or seep into the ground water. Solid products and wastes have the potential of dispersion by wind or water runoff from storage and disposal sites or spillage along transportation routes. These dispersing substances can pose a toxicity hazard to aquatic and terrestrial flora and fauna downstream or downwind from the plant.

Gaseous and particulate emissions from retort stacks can present environmental hazards if concentrations of emitted toxicants are not controlled adequately. Federal standards for emissions were set at levels considered safe for human and wildlife exposures. Since the gaseous emissions can have such widespread effects, and since Phase II emissions will be the worst case, their effects are discussed under Section 10, Chapter 5.3.

The second major type of processing facility airborne emission which may affect local flora and fauna is cooling tower salt water drift. Drift deposition rate projections are available for Phase II, which is the worst case. The discussion of salt drift impacts appears in Section 10, Chapter 5.3.

2. Mitigative Procedures - The area disturbance associated with Phase I processing operations can be partially mitigated by avoiding disturbance of areas beyond plan specifications during construction. Close-packing of individual structures may also minimize the total needed area of disturbance. Landscaping and revegetation of any open areas between facilities may reduce dust and noise propagation and improve the aesthetics. Mitigative procedures applicable to construction activities will be initiated at the onset of construction.

Spill contingency plans and runoff barriers and collection structures will limit the spread of liquid products or wastes beyond the immediate plant site area. Solid product or waste storage and disposal piles will be covered or surface-stabilized sufficiently to prevent wind erosion of the materials.

Gaseous and particulate emissions will be controlled as much as is feasible using the best currently available technology. The emissions will, in any case, be maintained below applicable state and federal regulated limits. Salt drift will be minimized as much as is feasible within the limits of current available technology.

B. Transition Phase

1. Impact Assessment - The area of disturbance for the processing operation, including beginning of construction of Phase II retorts (1982 to 1985), will increase approximately 55 ha (135 A). Associated losses of flora and fauna will be 117% greater than for Phase I.

Similarly, production of emissions will have increased along with start-up of the second retort. This will increase the potential for deleterious effects from these substances (as described under Phase II, Impacts Assessment for Processing).

2. Mitigative Procedures - Transition Phase mitigative procedures will be a continuation of Phase I policies and implementation of any new procedures necessitated by observations of the actual environmental impact during Phase I (by the monitoring program).

C. Phase II

1. Impact Assessment - Area disturbance by Phase II (1986) will have reached approximately 101 ha (250 A) (51% pinyon-juniper and 49% sage). All other effects of the operation will also have reached a maximum.

A potential for biological effects from Tract C-a development may accrue from concentrations of stack emissions (gases and particulates), affecting areas adjacent to the plant site. These emissions will reach a maximum during Phase II operations. The stated objective of the project is to meet all applicable standards for gaseous and particulate emissions. These standards are generally designed to prevent appreciable environmental degradation, including damage to native species. However, the present paucity of knowledge about species adapted to semi-arid regions like the Piceance Basin and a certain degree of uncertainty attributable to computer models of emissions in complex terrain require that the potential for biological damage by particulate and gaseous emissions be discussed in some detail.

In general, the potential for biological damage near Tract C-a from stack gases is greatest with regard to possible effects upon green plants, the primary producer component of local ecosystems. If emissions were to cause decreased vigor or even death of green plants over large areas, these effects would be felt throughout associated animal food webs. As vegetation tends to absorb gaseous emissions (Lamb, 1972), gaseous emissions pose a potential impact to Tract C-a vegetative communities.

Sulfur dioxide emissions present the greatest potential impact of air pollution effects in the vicinity of Tract C-a. Preliminary projections of SO_2 around the processing plant indicate that ground level concentrations will generally be well below the national primary and secondary standards. However, due to (1) projected concentrations approaching these standards on high ground to the north and west of the tract, (2) the possibility of local zones of concentration not presently predicted by the modeling effort due to the complex local topography, and (3) the possibility that some local species in this semi-arid region are unusually sensitive to SO_2, it is deemed important to discuss SO_2 and its potential effects more fully than other gaseous emissions.

Degree of injury is generally based upon rate of absorption of SO_2 which, in turn, is dependent upon the degree to which the stomata, the pores through which a plant "breathes", are open. In general, open stomata are most likely during periods of ample soil moisture, high relative humidity, moderate temperatures, and high light intensity. These conditions occur on and near Tract C-a in the early morning hours before 10 AM. These are the same hours within which higher SO_2 concentrations are expected to coincide with the almost daily occurrence of temperature inversions (Section 3, Chapter 6) during the spring and summer growing seasons.

The effects of SO_2 on plants may be summarized as follows: As SO_2 enters through the stomata and into the intercellular spaces of the leaves, it is absorbed on the moist cell surfaces (Daines, 1968). There the SO_2 reacts with water to produce sulfite ions which, in turn, are slowly oxidized to form sulfate ions (Barrett and Benedict, 1970). The sulfate ion may then be utilized by the plant as nutritional sulfur and be converted by the plant to an organic form (Thomas et al., 1943). Thus, at low ground-level concentrations of SO_2, the growth of some species may actually be enhanced as has been demonstrated for blue grama, one of the common grasses in the site vicinity (Johnson and Hevly, 1973). Exposure beyond these levels may lead to plant damage.

Chronic damage may result either from rapid accumulation of sulfite ions at sublethal concentrations during short-term exposure to high SO_2 concentrations, or from accumulation of sulfate ions to sufficient levels. In both cases, the leaf continues to function at a reduced level of efficiency proportionate to the amount of damaged tissue. Although cells are not killed, there is a bleaching of chlorphyll which appears as a mild chlorosis or yellowing of the leaf or a silvering or bronzing of the undersurface (Barrett and Benedict, 1970).

Acute injury results from rapid absoprtion of a toxic dose of SO_2. This injury appears as areas of dead cells which, at first, have a gray-green, water-soaked appearance. These areas later turn a bleached ivory or reddish-brown color upon drying. Eventually there is a random spotting of dead tissue between the leaf veins, with a sharp line of demarcation between necrotic and uninjured tissue (Barrett and Benedict, 1970).

Little information is available on the SO_2 sensitivity of most plant species found in the study area. In a series of field and laboratory tests of 53 southwest desert species, many of which are also found in the study area, the general conclusion reached was that "it takes relatively high concentrations of sulfur dioxide to damage the most common species native to the southwest region" (Lamb, 1972). This is consistent with the knowledge that the stomata are closed much of the time in species adapted to semi-arid regions as a means of conserving water. Nonetheless, two of the herbaceous species most common in the study area showed threshold damage at fumigation levels near the maximum levels expected around the Tract C-a processing plant. In laboratory tests, at SO_2 concentrations of 0.5-1.0 ppm and an exposure time of 3 hours (at or near secondary federal standards), a grass species commonly encountered in the Tract C-a study area, Indian ricegrass, showed definite evidence of pollution damage (Lamb, 1972; Johnson and Hevly, 1973). The same was true of a mountain mahogany species closely related to that encountered at Tract C-a (Lamb, 1972). Lowan et al. (1972) showed that injury to aspen occurred at concentrations of 0.39 ppm for 2-hour, and 0.26 ppm for 4-hour, exposure. These concentrations are well below present federal standards. Several other species common to the area have been shown to be damaged by SO_2 concentrations in the range of 1.0-2.0 ppm for a duration of 3 hours. These include big sagebrush, shadscale, inland saltgrass, and scarlet globemallow. Such species may prove useful as indicator species for use in the long-term monitoring program at Tract C-a.

Based upon SO_2 isopleth projections which show maximum short- and long-term concentrations for Phase II in the direction of Cathedral Bluffs (Section 6, Chapter 4.2), there is some concern about the isolated pockets of aspen and Douglas-fir which occur at the head of local drainages. Aspen is known to be highly sensitive to even low concentrations of SO_2 (Lowan et al., 1972), and Douglas-fir is known to be the second most sensitive of all conifer species. These two species are, therefore, more sensitive to SO_2 fumigation than most native or crop species (Treshow, 1970; Lowan et al., 1972).

Increased insect feeding damage and death of a variety of coniferous trees has been correlated with exposure to SO_2. Scheffer and Hedgcock (1955) found "massive" damage to Douglas-fir in areas receiving 5 ppm sulfur dioxide. In areas of the study which were receiving close to 1 ppm, the authors postulated that trees were sufficiently reduced in vigor by SO_2 exposure and that significant damage was done by bark beetle infestations.

Most of the existing entomological literature on sulfur dioxide deals with two major areas of research, the effects of sulfur dioxide fumigation on honeybee hives, and the synergistic effects of sulfur dioxide damage and insect damage to plant species. Hillman (1972) found that chronic exposure to 1-2 ppm sulfur dioxide caused statistically significant reductions in worker bee longevity, worker bee flight activity, and smaller increases in colony weight over the summer. He also found that the workers collected less pollen, which is needed in large amounts for brood formation. The loss of pollen, coupled with erratic queen behavior, resulted in statistically significant reductions in the amount of brood production.

An additional uncertainty which makes the prediction of effects by SO_2 on vegetation difficult is the possibility of interactions (synergism) between SO_2 and other gaseous emissions. Although predicted emissions of nitrogen oxides (NO_x) are extremely low, it has been shown that concentrations of SO_2 and NO_x or SO_2 and ozone, which would not be detrimental by themselves, may act synergistically to cause visible symptoms of plant injury (Heck, 1968; Menser and Heggestad, 1966). Too little information is currently available to predict the likelihood of synergistic effects from such combinations of gaseous pollutants, but the "possibility" is sufficient to require that local vegetation communities be monitored even if all applicable standards for each emission are being met.

Particulate emissions are second to gaseous emissions in the potential of affecting areas around an emission source. While there are no standards governing the emission of trace elements with stack gases or salt drift from cooling towers and spent shale moisturizers, both should be discussed as having a potential for negative environmental impacts. Potential emissions include arsenic, fluoride, mercury, selenium, and others. However, it is not presently known how much, if any, of these trace elements will be emitted from the Tract C-a operation.

In order to accurately assess the potential for damage to local vegetation from trace elements in stack particulates, additional information is needed. First, a broad scan trace element survey in the area of concern (Section 3, Chapter 12) must be used to define existing trace elements in the natural environment. Then, on the basis of knowledge about trace elements contained in oil shale and the percentages of these to be vented with stack gases, it can be judged whether any new trace element problems will be created or existing problems accentuated by operation of the retorts. This data can only be gathered and control techniques developed after actual operation of the retorts and the gas clean-up system.

Toxicity to vegetation would, of course, decrease the total energy flow through the local ecosystem. Chlorosis and necrosis to local vegetation is, however, not the only area of possible negative impact of the gaseous and particulate emissions. Talisayon (1972) has suggested that animal susceptibility to fumigants may be much closer to vegetation susceptibility than suggested earlier by Lillie (1970). Also, there is the possibility of pulmonary or other tissue (histological) damage or reduced resistance to parasitism and disease (interference with immunological systems) in areas of highest SO_2 and NO_x concentrations (Novakova, 1965; McArn et al., 1974; Tashio et al., 1973; Takemoto et al., 1974).

Local damage or destruction of the soil microarthropods due to gaseous or particulate emission toxicity could interfere with nutrient cycling by retarding litter decomposition (Barrett, 1968). Any such reduction in available nutrients could contribute to decreased forage and browse productivity by promoting accumulation of nutrients in undecomposed litter.

There are recorded examples of deleterious effects of emissions on insect predator or parasite populations including: particulate matter decreasing parasitic wasp populations resulting in an aphid population increase (Hillman, 1972), and decreases in numbers of insect parasites of an insect pest species where trees were severely affected by SO_2 fumigation (Heagle, 1973).

Preliminary projections of salt drift were performed for cooling towers. Salt drift from cooling towers was predicted on the basis of (1) a diffusion equation model which predicts higher rates of salt accumulation on the ground closer to the cooling towers, and (2) a trajectory model which predicts slower rates of accumulation at greater distances from the towers. It is expected that the true physical picture will be somewhere between the two extremes.

Salt drift may affect local vegetation through direct impingement on leaf surfaces or effects on soil salinity; both avenues of effect may ultimately produce the same results, a change in species composition or, in extreme cases, a complete loss of plant cover within affected areas.

Saline cooling tower drift may affect nearby vegetation through the impingement and sedimentation of aerosol droplets on foliage with subsequent uptake into the leaves. Sensitivity to foliar salt deposition appears to vary widely among species and to be strongly dependent on accompanying relative humidity conditions (McCune et al., 1974; Moser, 1975). High humidity conditions tend to increase the injury associated with a given aerosol concentration, possibly by facilitating absorption into the leaves; however, humidity is relatively low on Tract C-a.

Within a given category of plants, broad-leaved shrubs for example, morphological differences may account for vast differences in the sensitivity of different species to salt. Saline droplets impinging on heavily cutinized or densely hairy, pubescent leaves will much less likely be absorbed than droplets landing on thinly cutinized, glabrous leaves. Likewise, leaves with a heavily cutinized upper surface with few or no stomata may be relatively immune to salt drift effects in comparison to plants with stomata equally distributed on upper and lower leaf surfaces. In winter, inversion effects may cause increased ground exposure to the cooling tower plume. However, this problem will be somewhat alleviated due to a reduction in cooling operations during cold weather.

Many plant species existing in this area are adapted to saline conditions (halophytic species) and these exhibit substantial levels of sodium and chloride in leaf and stem tissues under normal conditions. In fact, several of these species actively excrete salts at the leaf surface. It is not likely that such species will be adversely affected by moderate salt accumulation from cooling tower drift.

If a number of assumptions are made for local physical conditions (some of which have questionable applicability to Tract C-a and environs), some reasonable projections of salt drift accumulations and their effects on soil salinity and, in turn, upon plant community composition may be made. First, assume that the local upland soils are moderately permeable, slopes are slight to moderate, and that most precipitation comes as snow or as medium-intensity/short-duration rainstorms. It follows that all or most moisture would soak into the ground, taking salts deposited on the soil surface with it. Assume further a uniform distribution of annual precipitation in the uppermost 35 cm (14 in) of soil by penetration to that depth and a soil weight of 4.48×10^6 kg/ha (4×10^6 lb/A). Based upon these assumptions and the maximum rate of salt accumulation projected by the trajectory model (225 g/m^2/yr at 150 m northwest of the tower), it would take approximately 3 years for salt concentrations to reach 0.15% which is a level associated with "slightly" saline soils affecting sensitive species such as big sagebrush. After 7 years, the level would approach 0.35% and a classification as a "moderately" saline soil affecting most of the species currently growing in the area.

How far, then, would this influence extend? Using the lowest rates of accumulalation projected by the same model but different inputs (5 $g/m^2/yr$ to distances of as much as 450 m (1,476 ft) downwind), the slightly saline effect would not be achieved for 131 years. Thus, by this model, we would expect the effects of salt drift, resulting in modifications of plant communities, to attenuate from the tower with little or no impact extending beyond 450 m (1,476 ft) from the tower. This treatment may be somewhat over-simplified in that it neglects the unknown rates of salt removal from the area by surface runoff and soil percolation deeper than 35 cm (14 in). However, the low rates of soil salinity accumulation will not create major short-term impacts. Local halophytic plant species include: four-wing saltbush, shadscale, winterfat, black greasewood, gray horsebrush, rubber rabbitbrush, dwarf rabbitbrush, broom snakeweed, eriogonums, milkvetches, chenopods, and several grasses. In contrast, the most severe toxic effects will likely occur among the more common broad-leaved shrubs such as Utah serviceberry, mountain snowberry, big sagebrush, true mountain mahogany, and wax currant if the salt drift reaches these species (Section 3, Chapter 7.1).

The areal extent of effects to vegetation will be largely determined by wind conditions and cooling tower design (primarily height and salt concentration of drift droplets). Most of the larger water droplets (>200 μ) will settle out very rapidly and not be airborne beyond 200 to 300 m (656 to 984 ft) from the source. Smaller particles can be carried considerably farther, especially in moderate to high winds. However, the further they are carried, the more dispersed the drift will become, resulting in much lower effective concentrations. Annual deposition rates and areal coverage by the proposed cooling towers are projected in Section 9, Chapter 5.7.

In addition to direct effects of saline aerosols upon local vegetation, the salt drift deposited near the cooling towers may accumulate in the soils primarily in the perimeter of the plant to levels which may adversely affect local vegetation. The relative rate of accumulation in the soil versus dissolution and transport in precipitation runoff will be strongly dependent on precipitation patterns, topography, and soil permeability. For the actual site involved, the permeable soils, slight to moderate slopes, and a predominance of low intensity rainstorms would lead to a relatively high proportion of infiltration as opposed to runoff.

Although precise changes cannot be predicted, salt accumulation in soils may cause a decrease in salt intolerant, shallow-rooted species such as mountain snowberry, antelope bitterbrush, wood rose, wax currant, arrowleaf balsamroot, blue grama grass, prairie junegrass, needle-and-thread grass, penstemon, and lupine. In comparison, the relatively salt-tolerant taxa such as wheatgrass, wildrye, four-wing saltbush, shadscale, winterfat, and black greasewood could be at a competitive advantage. Deep-rooted species would also be favored.

2. Mitigative Procedures - The mitigative plan for Phase I and the Transition Phase will be continued. The knowlege acquired in Phase I will be incorporated to enhance the mitigation plans used for Phase II.

5.4 PROCESSED SHALE AND OVERBURDEN DISPOSAL

A. Phase I

1. Impact Assessment - Three separate areas will be disturbed as a result of Phase I waste disposal:

- An overburden disposal area of approximately 55 ha (137 A) (68% sagebrush, 32% pinyon-juniper)
- A processed shale disposal area of approximately 28 ha (68 A) (91% pinyon-juniper and 9% sagebrush)
- A topsoil storage area of approximately 8 ha (20 A) (88% pinyon-juniper and 12% sagebrush)

In addition, approximately 16 ha (41 A) (42% pinyon-juniper, 30% mixed brush, and 28% sagebrush) will be destroyed during overburden haul road construction and 13 ha (32 A) (53% sagebrush and 47% pinyon-juniper) will be cleared during construction of the processed shale haul roads.

The habitat of the area cleared for the disposal and storage piles and the haul roads is sufficient to support 63 to 794 least chipmunks and 63 to 529 deer mice in pinyon-juniper, 114 to 359 least chipmunks and 62 to 166 deer mice in sagebrush, and 10 to 22 least chipmunks and 5 to 38 deer mice in mixed brush.

The area will also represent an additional reduction in available habitat for other small mammals, birds, reptiles, invertebrates, and ungulates.

The most important avian species in the area to be disturbed by Phase I processed shale and overburden disposal and haul road construction include: the horned lark, scrub jay, black-billed magpie, mountain chickadee, bushtit, mountain bluebird, gray and solitary vireos, black-throated warbler, and chipping sparrow in the pinyon-juniper; vesper, Brewer's and sage sparrows, yellow-rumped warbler, mountain bluebird, and horned lark in the sagebrush habitat; and black-billed magpie, mountain bluebird, blue-gray gnatcatcher, and dark-eyed and gray-headed juncos in mixed brush habitat. Assuming that losses in breeding habitat will result in a reduction in the area's bird population, it is estimated that clearing of 63 ha (156 A) of pinyon-juniper could result, for example, in the loss of habitat for 50 to 89 black-throated gray warblers, 12 to 100 mountain chickadees, and 19 to 100 mountain bluebirds.

The clearing of 52 ha (128 A) of sagebrush may result in the loss of habitat for 1 to 5 mountain bluebirds, 16 to 62 vesper sparrows, and 26 to 73 Brewer's sparrows. The clearing of 5 ha (12 A) of mixed brush could result in habitat losses for 1 to 5 blue-gray gnatcatchers.

The haul road passes near an active red-tailed hawk's nest and in close proximity to two areas at which peregrine falcons were sighted and one prairie falcon was recorded. However, none of the areas where peregrine and prairie falcons were sighted are considered suitable nesting habitat for these species and nests were not located anywhere nearby. The continual activity along this road will probably eliminate breeding activity at the red-tailed hawk's nest by causing the pair to abandon the area.

The status of the peregrine falcon in the study area is still undetermined. This falcon is probably uncommon to the area. It is presently unknown how significant destruction of portions of an individual raptor's hunting range is to the livelihood of that individual. It was proposed, for example, by Gerald Craig, chief raptor biologist for the Colorado Division of Wildlife (personal communication, 1975) that the two peregrines observed in the study area during the late summer were adults feeding at the limits of a possible 32.2-km (20-mi) hunting radius around a suspected eyrie. The Federal Recovery team of the western peregrine falcon (U.S. Fish and Wildlife Service) established guidelines for development around a peregrine eyrie. One guideline states that no major industrial activities within prime hunting habitat (defined as a 16.1-km (10-mi) radius around the eyrie) (Dr. Jim Enderson, personal communication, 1975). If peregrine falcons are nesting within 16.1 km (10 mi) of the tract, Corral Gulch could be considered prime hunting habitat for a breeding pair. However, the only known possible eyrie at this time is located 32.2 km (20 mi) southeast of Tract C-a and the study area is poor potential nesting habitat.

The processed shale disposal site is in close proximity to the areas in which greater sandhill cranes were observed during their fall and spring migrations. Whether these birds are part of the Colorado breeding population is undetermined at present.

Dry, windy weather can erode exposed processed shale at a rapid rate, possibly spreading considerable quantities of processed shale dust into the surrounding vegetation. Successful revegetation of the processed shale pile is essential in the long term if it is to be protected from erosion.

The overburden disposal pile will result in wildlife losses proportionate to the area and vegetation type disturbance as described in Section 10, Chapter 5.1. This pile will also be subject to wind and water erosion and, possibly, leaching of toxic substances.

The topsoil storage pile will contribute a relatively small additional area loss to wildlife (8 ha; 20 A).

Dust and bulk material spillage along haul roads to the disposal piles could contribute to degradation of adjacent habitat. This is especially true of escape of processed shale which has a higher toxicity potential than either overburden or topsoil.

2. Mitigative Procedures - The area disturbance can, in this case, be partially mitigated beyond just minimizing it. Revegetation of disposal and storage piles will contribute to restoration of lost habitat.

Standard noise and dust control procedures for equipment operation (Section 9, Chapters 4 and 5) should hold these problems to a minimum. The piles themselves may require chemical or mechanical surface stabilizers/binders to minimize wind and water erosion. Portions of the processed shale pile which have crusted over will be protected from disturbance of the crust. The runoff collection pond will be fenced to prevent its use by deer, horses, cattle, and other wildlife if the quality of the water is unacceptable for wildlife use.

Any signs of pile slump or collapse will be promptly investigated so adjustments can be made in the disposal plan (if needed) before massive failure results in topsoil losses or spread of wastes over unpredicted areas.

Since brush and trees removed during clearing operations may contain a large proportion of the available nutrients for the acreage, it is important that they be returned to the area. This may be done by mulching (Section 9, Chapter 8).

B. Transition Phase

1. Impact Assessment - During the Transition Phase, the area disturbance will have reached approximately:

- 47 ha (117 A) for the overburden disposal area (60% sagebrush and 40% pinyon-juniper)
- 23 ha (58 A) for the processed shale disposal area (75% pinyon-juniper and 25% sagebrush)

The area of the haul roads and the topsoil storage pile will remain the same as in Phase I.

Noise and dust of disposal activities will increase along with the accelerated pace of the mining and processing operations. As disposal piles increase in area, their susceptibility to erosion will also increase. However, the revegetation of 81 ha (202 A) of the two disposal sites and 8 ha (20 A) seeded of the topsoil storage area should partially alleviate this problem.

Assuming successful revegetation of completed portions of the piles, the erosion and pile collapse risks of the Transition Phase piles will not be significantly different from Phase I.

2. Mitigative Procedures - The same precautions and control measures discussed for Phase I pertain here. In addition, the importance of successfully revegetating completed portions of the disposal piles is greatly increased and is much greater than in Phase I. If revegetation cover establishment proceeds too slowly to provide adequate surface stabilization, artificial erosion control measures may have to be continued or even expanded.

C. Phase II

1. Impact Assessment - Total area disturbed will have reached 656 ha (1,620 A) (64% sagebrush and 36% pinyon-juniper) for the overburden pile and 984 ha (2,430 A) (72% pinyon-juniper and 28% sagebrush) for the processed shale pile during Phase II. If revegetation is progressing well, 1,632 ha (4,030 A) on the disposal pile and 8 ha (20 A) on the topsoil pile active areas will be in varying stages of rehabilitation, and recovery of wildlife populations in the revegetated areas should be underway.

The construction of the processed shale conveyor will result in the additional removal of pinyon-juniper and sagebrush habitat on 84 Mesa. Dust and noise are not expected to be worse than during the Transition Phase if processed shale dust is adequately controlled.

Total runoff area will have increased greatly, thereby maximizing the potential burden on the runoff collection system. This also would make any failures of the control system more serious to the welfare of local flora and fauna. The piles are designed and will have been laid out so the chances of this happening are slim. If long-term revegetation is not successful, runoff control will have to be continued indefinitely.

2. Mitigative Procedures - The policies and practices given under Phase I and the Transition Phase, including the monitoring plan, will be continued. The disturbed area along the processed shale conveyor route will also be rehabilitated as much as is feasible. All necessary steps will be taken to assure revegetation success.

5.5 SUPPORT FACILITIES

A. Phase I

1. Impact Assessment - The four major areas of impact due to support facilities during Phase I will be:

- Internal roads (on site) - approximately 67 ha (166 A) (54% pinyon-juniper, 32% sagebrush, 8% upland meadow, and 6% mixed brush)
- Product pipeline (on site) - approximately 6 ha (16 A) of disturbance (63% pinyon-juniper and 37% sagebrush)
- Mine support facilities - truck shop, change house, etc. will disturb approximately 10 ha (25 A) (85% pinyon-juniper and 15% sagebrush)
- Power distribution network (area unknown)
- Water control facilities will inundate approximately 57 ha (140 A) (vegetative composition unknown)

The sum of all areas disturbed by support facilities during Phase I will result in the removal of pinyon-juniper sufficient to support 49 to 617 least chipmunks and 49 to 412 deer mice, of sagebrush sufficient to support 55 to 172 least chipmunks and 30 to 80 deer mice, and of mixed brush sufficient to support 8 to 17 least chipmunks and 4 to 30 deer mice.

The most important avian species in the area to be disturbed by Phase I support facilities include: the horned lark, scrub jay, black-billed magpie, mountain chickadee, bushtit, mountain bluebird, gray and solitary vireos, black-throated gray warbler, and chipping sparrow in the pinyon-juniper; vesper, Brewer's and sage sparrows, yellow-rumped warbler, mountain bluebird, and horned lark in the sagebrush habitat; black-billed magpie, mountain bluebird, blue-gray gnatcatcher, and dark-eyed and gray-headed juncos in mixed brush habitat; horned lark, chestnut-collared longspur, and vesper, Brewer's and white-crowned sparrows in upland meadow habitat.

Assuming that removal of breeding habitat will translate into carrying capacity elimination losses of birds as described in Section 10, Chapter 5.1, it is estimated that clearing of 49 ha (121 A) of pinyon-juniper for the support facilities during Phase I could result, for example, in removal of habitat that could support 39 to 59 black-throated gray warblers, 10 to 78 mountain chickadees, and 15 to 78 mountain bluebirds. The clearing of 25 ha (62 A) of sagebrush may result in removal of habitat that could support 3 to 34 mountain bluebirds, 8 to 29 vesper sparrows, and 18 to 51 Brewer's sparrows. The clearing of 4 ha (10 A) of mixed brush could result in habitat losses for about 1 to 7 blue-gray gnatcatchers. Clearing of 4 ha (10 A) of upland meadow may result in the removal of habitat that could support one to three horned larks, one to three vesper sparrows, one to three Brewer's sparrows, and two to three chestnut-collared longspurs.

Noise along the access roads will produce a narrow adjacent band of disturbance to the more sensitive species. Dust suppression with water along unpaved portions of the roads or winter slating could result in reduced vigor of roadside vegetation when salt buildup washes off roads in the spring. Paving and standard mechanical snow removal procedures will practically eliminate these latter two potential problem areas. Vehicular and equipment exhaust emissions will contribute somewhat to airshed pollutant levels.

Besides the area disturbance, the most likely harmful effects are accidental spills. Pipeline or channel breakage or storage pond leakage or rupture could result in serious local erosion damage and possibly allow escape of unacceptably low quality well or runoff water into stream courses. Sewage wastes (water and sludge) will be treated and disposed of in a suitable manner (Section 9, Chapter 6) to avoid possible contamination of surface or ground water.

The product pipeline area disturbance is relatively small in the immediate vicinity of the plant site. The greatest danger of the product pipeline will be the possibility of rupture and resultant spill of shale oil onto the ground surface. The exact impact of such an occurrence would depend largely on the amount spilled, but would, in any case, result in at least localized damage to plant and animal life through surface coating and/or direct toxicity (Section 9, Chapter 7).

The mine support facilities located east of the pit will contribute additional habitat removal. Planned control (collection) of truck shop waste (oil, fuel, etc.) spillage makes local environmental pollution from this source unlikely (Section 9, Chapter 7).

The power distribution network to the wells, the mine, the plant site, and other facilities will disturb a certain surface area, most of which can promptly be revegetated. This system has a potential impact on raptorial birds. Eagles and hawks prefer to perch on elevated sites such as powerlines and associated support structures where prey species might be observed over a wide radius and where air currents are more favorable for flight. Power poles make excellent perches for these birds.

The construction of a utility line would be potentially the second most dangerous impact to the raptor (particularly the golden and bald eagles) population in the region. Powerlines that traverse flat, broad valleys where natural perch sites are absent obtain more use than those powerlines located in steep and broken terrain with many natural perches. The proposed powerline for Tract C-a traverses broad rolling country rather than steep, broken terrain.

2. Mitigative Procedures - Area disturbance will be held to a planned level. Standard construction dust control measures will be practiced. Rehabilitation of product pipeline and power distribution route disturbances will be promptly undertaken to minimize erosion potential and hasten re-establishment

of productive wildlife habitat.

Raptor perches will not be provided on main powerlines from the White River to Tract C-a because the lines are 20 feet apart; this type of construction will not present an electrocution hazard to raptors. Power distribution lines around Tract C-a will either have raptor perches or be grounded. This will minimize the risk of electrocution to the larger raptorial birds.

B. Transition Phase

1. Impact Assessment - The impacts will remain categorically the same as for Phase I, but the increased flow of people and materials will proportionately increase the probability and severity of accidents and spills.

2. Mitigative Procedures - The procedures and precautions for Phase I still pertain to the Transition Phase activities. In addition, rehabilitation success of the pipeline corridors should be reviewed to determine if additional effort is necessary.

C. Phase II - (Support Facilities)

1. Impact Assessment - Material flux will reach a maximum during Phase II. The load on the support facilities will be the greatest at this time, maximizing the potential for environmental degradation due to spills.

In addition, approximately 106 ha (260 A) of vegetation comprising sagebrush (52%), bottomland meadow (15%), shadscale (14%), pinyon-juniper (11%), riparian (6%), and rabbitbrush (2%) will be disturbed during Phase II by construction and use of the water control system. This includes the dam, dike, and reservoir near 84 Ranch and the groundwater pipeline to the reservoir.

Habitat carrying-capacity removal due to this disturbance could support 121 to 380 least chipmunks and 66 to 176 deer mice in sagebrush and 15 to 185 least chipmunks and 15 to 126 deer mice in pinyon-juniper. The area might also support as many as approximately 64 to 85 cottontail rabbits.

The most important avian species in the area to be disturbed by water control facility development in Phase II include: vesper, Brewer's and sage sparrows, yellow-rumped warblers, mountain bluebirds, and horned larks in the sagebrush habitat; horned larks, black-billed magpies, western meadowlarks, and red-winged blackbirds in the bottomland meadow habitat; and horned larks, scrub jays, black-billed magpies, mountain chickadees, bushtits, mountain bluebirds, gray and solitary vireos, black-throated gray warblers, and chipping sparrows in the pinyon-juniper habitat. Area disturbance will result in a reduction of habitat for these species.

The water reservoir near 84 Ranch has a potential for benefiting wildlife. The production of suitable wildlife habitat associated with the reservoir is predicated on two requirements:

- Water quality must remain high enough to support plant and animal life
- Water level fluctuations must not be extreme, particularly during the growing/breeding season.

Since the exact reservoir water quality and quantity expected cannot now be determined, the degree of water-margin plant, and associated animal, productivity is unpredictable at present. Meeting the two requirements listed above could more than compensate for riparian habitat losses due to mine dewatering effects on seeps and springs locally. Such open-surface water impoundments as this reservoir could also contribute to the local population of insect pest species (e.g., mosquitoes), but in the process provide food for several species of wildlife.

2. Mitigative Procedures - The procedures and precautions of Phase I and the Transition Phase are equally applicable in Phase II. In addition, water control and conveyance structure condition (dikes, ditches, pipelines, etc.) will be monitored and maintained, and the water level in the water storage reservoir will be maintained as constant as is feasible.

5.6 SUMMARY BY IMPACT CATEGORY

The preceding sections have discussed the terrestrial ecological effects of individual segments of the total operation for oil shale Tract C-a. This section will summarize the primary impacts associated with the major categories of activity of the Tract C-a oil shale development. A worst-case situation is assumed to be Phase II for most impact categories. Special deviations from this assumption will be pointed out in the text.

Direct impacts of development will result from:

- Area disturbance
- Processing facility emissions
- Mine dewatering
- Dust
- Noise

The indirect effects of increased human presence will be discussed immediately following the discussion of the direct effects categories listed above.

A. Area Disturbance - By the end of the Phase II impact assessment period (December 2015), approximately 2,340 ha (5,755 A) will have been disturbed by development activities. The greatest losses will be of sagebrush and pinyon-juniper (42% and 41%, respectively), and mixed brush (13%). Lesser amounts of shadscale, upland meadow, agricultural, riparian, and rabbitbrush will also be eliminated.

The removal of this vegetation will result in elimination of the associated mammalian, avian, and invertebrate herbivores with a concomitant reduction in food supplies for local predator populations. Small mammal elimination will be on the order of two to five individuals per hectare of the most abundant species (least chipmunk and deer mouse). Habitat supporting one cottontail will be eliminated for every 1 to 2 ha (3 to 4 A) disturbed.

The greatest impact of area disturbance to avifauna is the removal of nesting habitat. This impact can be counted as a reduction in the local breeding population of birds for those species utilizing the areas disturbed.

Ungulates will be excluded from use of much of the disturbed area. This may place an additional burden on rangelands outside of the developed area. Competition between and among horses, cattle, deer, and elk for food may cause deterioration of range and browse condition and result in decline in the condition and abundance of these large mammals locally. The presence of the development may produce a localized interference with the deer herd movements between winter and summer ranges.

Invertebrate populations will be largely eliminated from the disturbed areas. Most of the flying insects will escape the disturbance, possibly temporarily elevating the degree of insect herbivory in adjacent areas. Bees will probably not escape since the queen would be destroyed with the nest. Lizards will be eliminated from the disturbed area along with their invertebrate prey.

Avian and mammalian predators will have their available hunting territory reduced by the amount of the disturbed area. Since food supply may be a limiting factor for predator populations, the removal of the development area may result in a reduction in predator numbers in the study area proportionate to decreases in their prey populations. Because predators are frequently very wide-ranging and the area disturbed by development is small relative to the study area, any predator population reduction resulting from the operations around Tract C-a will be small.

At present, no unique species or critical habitat are known to be included in the area of disturbance. Riparian habitat is uncommon locally and the loss of even a small amount will probably result in a sharp drop in species which depend on it for survival and for which there is no alternate habitat in the vicinity. Protected species such as Astragalus lutosus or the peregrine falcon (nesting) have not been located in the area of disturbance (Section 3, Chapter 7.2), so no impact is expected on any species with a special legal status. Greater sandhill cranes have been seen in the area (84 Mesa), but their legal status in Colorado is dependent on their nesting in the state. No nesting cranes have been located to date locally (Section 3, Chapter 7.3).

The impacts of area disturbance can be mitigated by minimizing the total area disturbed, by revegetating such disturbed areas if and when able, and by replacing or enhancing wildlife habitat.

Revegetation will take place in peripheral areas disturbed during construction, pipeline and transmission corridors, and on disposal piles. The establishment of a permanent, self-propagating ground cover on reclaimed areas, including the disposal piles, is essential to long-term surface stabilization and to eventual habitat restoration.

B. Processing Plant Emissions - Gaseous and particulate emissions, if present in high enough concentrations, can have a profound negative impact on local flora and fauna. Stack gases can be toxic, causing chlorosis or necrosis to plants or pulmonary tissue damage, interruption of the immunologic response, and other undesirable physiological changes in vertebrates. Many species of invertebrates including bees, an important pollinator group, are also sensitive to various fumigants. In any case, severe plant damage or vegetation type changes, if they occur, will effect concomitant changes in the associated fauna due to reduction in total available food.

Cooling tower salt water drift may contribute to vegetation condition deterioration or vegetation composition or type changes where deposition rates are high enough to cause leaf contact damage or increasing soil salinity. Soil salinity increases may be directly toxic or may harm plants by increasing plant water stress past tolerable levels. Salt drift will be restricted to an area within 450 m (1,476 ft) from the cooling towers.

Products, by-products, and wastes of oil shale processing will be carefully transported and disposed of.

Impacts of gaseous and particulate emissions and salt drift can only be mitigated to the extent that the quantities of these emissions are minimized.

Emission control equipment will be maintained to minimize the output of gases and particulates.

C. Mine Dewatering - Recent projections suggest that mine dewatering on Tract C-a may affect groundwater tables over a wide region. This implies that springs in the area fed by the oil shale aquifers may suffer diminished or eliminated water flow except for those springs (if any) supplied by perched aquifers. Upper elevation springs may be less affected by mine dewatering. The decreased water supply from seeps for stream course vegetation and associated wildlife will result in reductions in population densities of this wildlife.

If dewatering lowers water levels in the major spring (Stake Springs) to the point where adverse impacts occur, then augmentation will be undertaken as required.

D. Dust - Ambient natural levels of dust in the air in the Piceance Basin approach or exceed government standards (Fosdick and Legatski, 1975). Thus, any additional contribution to this dust load may result in exceeding those standards.

Dust may impact local flora and fauna in several ways. In severe cases, leaf surfaces may be coated and stomates clogged sufficiently to interfere with photosynthesis. Vertebrate lung tissue may accumulate minute dust particles and fine dust may interfere with insect surface respiration, but neither effect will be serious except, possibly, immediately adjacent to long-term dust sources.

Construction activities have the greatest initial potential for dust production and require constant attention to control during the dry months. After construction is completed and the development is fully operational, the major dust production potential will be from processed shale and overburden pile wind erosion, road dust, mining dust, and conveyor dust. Mining dust will mostly settle back in and near the pit and dust production will be controlled by watering. Conveyor dust will be controlled by mechanical means (Section 9, Chapter 5). Disposal pile dust will be controlled by watering, use of chemical or mechanical surface stabilizers, and the timely re-establishment of a vegetation ground cover.

Despite dust control efforts, some long-term dust effects are expected in a fairly narrow band along unpaved haul roads. Within this narrow roadside band, the health and vigor of plants and animals will be diminished moderately.

E. Noise - Noise production can be substantial for some operations. Haul trucks, conveyors, crushers, and other mechanical equipment may be point sources of noise levels up to 90 to 120 dbA (at 50 feet). These levels exceed the federal regulation levels for 8-hour exposure of humans. It might, therefore, be expected that resident animals very near these sources of noise would suffer some physiological or psychological effects, resulting in diminished population densities of moderately sensitive species of mammals and birds immediately adjacent to the noise source. This effect will attenuate rapidly as distance from the noise source increases.

Because most of these noise sources are surrounded by or enclosed within larger areas of physical disturbance (e.g., mine pit, plant site), the greatest exposure of wildlife to noise is expected along haul roads. Constant, heavy truck traffic will contribute to a narrow roadside zone of reduced mammal and bird abundance.

Mitigation of noise impacts will be largely limited to maximum feasible reduction at the source. Noise suppression equipment, trucks, and other equipment will be kept in good working order. Some moderate amount of noise control may be exerted by landforms (embankments) and vegetation.

F. Human Presence - The increased numbers of people visiting, using, and working in the area due to oil shale development activities for Tract C-a will have concomitant, indirect effects not specifically related to the development activities. For example, increased traffic on area roads will increase wildlife-vehicle collisions ("road kills").

Range deterioration may result from competition between and among deer, horse, and elk populations for food resources if the oil shale development results in concentration of these animals in a reduced range in the western half of the study area. This deterioration in range condition would result in attendant population size and/or physiological condition deterioration of the animals.

Introducing increasing numbers of humans to a previously relatively remote area might be expected to greatly increase hunting pressure (both in and out of season) on local game populations. Increased (unrestricted) off-road vehicle use west of the tract may result in range and slope deterioration and could also increase disturbance to wildlife from human presence discussed above.

Road kills can be minimized by reducing total traffic volume and velocity. This might be accomplished by car pooling or commercial busing and reduced speed limits or engineered physical roadway speed controls. Deer drift fencing is discussed in Section 9, Chapter 11. Hunter access to areas adjacent to the tract may have to be restricted if hunter pressure becomes too great.

5.7 OVERVIEW

The preceding sections have discussed the impacts and their associated mitigative procedures of individual operations of oil shale resource development for Tract C-a. The objective of this final section is to give a brief, generalized overview of the effects of the operation as a whole to the ecosystem within the entire study area. This approach allows the reader to view the individual and the overall impacts in a broader perspective. In contrast to Section 10, Chapter 5.6, this section will discuss the effects of the whole operation on each trophic level and the ways in which these effects might be interactive throughout the ecosystem locally.

By December 2015, approximately 2,340 ha (5,755 A) of vegetation will have been disturbed by surface activities associated with Tract C-a oil shale development. Development at this time will result in a total surface disturbance of approximately 50% of the nearly 4,600 ha (11,400 A) lease area (Tract C-a, 84 Mesa disposal area and processing site), even assuming that no substantial reclamation of disturbed land will have taken place. This loss of vegetation is predominantly pinyon-juniper and sagebrush, with lesser amounts of mixed brush and other vegetation types. During Phase II, approximately 1,700 ha (4,300 A) will be either in the process of, or final stages of, rehabilitation. In addition, wildlife enhancement procedures (Section 9, Chapter 11) will have done much to alleviate impacts due to area disturbance.

Stack gas dispersion over an area adjacent to the development may contribute to reduced vigor of vegetation, especially if there are unpredicted areas of anomalously high fumigant concentrations. A fairly localized additional loss of vegetation will occur immediately downwind of the cooling towers due to salt drift deposition, resulting in foliar damage and increased soil salinity. Both these impacts have the potential for direct gross productivity reduction and vegetation type or association changes in the areas affected.

Mine dewatering has the potential to contribute to the removal of important riparian habitat in Stake Springs. However, if water levels in this spring drop due to mine dewatering, RBOSP will provide augmentation as required.

Some of the losses of vegetation will be recovered by rehabilitation efforts (Section 9, Chapter 8). Most revegetation will take place in peripherally disturbed areas (roadsides and around other construction sites) and on the disposal piles. In addition, mine pit backfilling and surface rehabilitation is expected to start after approximately 30 years of pit operation.

Losses of vegetation represent a reduction in the carrying capacity of the whole study area. Because the severity and extent of damage to vegetation due to gaseous emissions, salt water drift and mine dewatering (the three direct effects most likely to be felt beyond the immediate site vicinity) are not precisely predictable, this productivity loss can only be discussed in generalized terms. In any case, the long-term loss should be minimal - in the range of 2 to 5% of the study area.

Total vegetation removal in an area also results in the total elimination of resident herbivores. Only very mobile animals will be able to escape from areas being cleared. Most small mammals, reptiles, and invertebrates will be eradicated during the vegetation removal operations. Even those mobile animals which do disperse to areas adjacent to those disturbed will be subject to increased predation and competition for resources with animals already resident there.

This increased competition for food resources could be substantial over the whole study area if displaced animals, along with resident animals, exceed the carrying capacity of the remaining range. Although exceeding range capacity is unlikely, it does leave the possibility of contributing to localized range deterioration if such go unnoticed. The recreational/economic importance of deer in the Piceance Basin makes possible range deterioration a serious concern.

The present protected status of feral horses makes their management at the present time difficult. This status presents the potential for concentrated horse populations to place undue grazing and browsing pressures on the rangeland. However, if horse populations exceed carrying capacity causing a deterioration of range condition, it is expected that the responsible government agencies will enact steps to manage their populations.

The most efficient predator throughout the area must be considered to be man. Besides productivity cropping through ranching and hunting, human influence can extend into all phases of ecosystem functioning. The predicted direct impacts of the oil shale development were summarized above along with a discussion of some possible biotic or ecosystem repercussions of these direct impacts.

Human presence may, by itself, create additional problems. These may include, among many possible effects: increased local hunting pressure as more people are introduced to a previously fairly remote area; increased disturbance of species attractive to man such as feral horses and some raptorial birds; and deterioration of range from increased off-road vehicle use.

Overall, the loss of the developed area from productivity is expected to contribute a moderate destabilizing influence on the vegetation-herbivore interaction in the study area. Any eventual reduction in herbivore numbers due to the influence of the development will also be reflected in predator populations.

This effect may not be manifested as a reduction in predator numbers. Instead, important predators, notably the coyote, may shift prey species. If the shift was toward deer and domestic livestock, it could be locally serious for these economically important species. If, on the other hand, mammalian predators are food-limited locally already, a reduction in productivity throughout the local lower trophic levels in the ecosystem would also be reflected, areawide, in proportionately reduced predator populations as well.

Many avian predators (raptors) are limited by availability of species nesting habitat rather than food. Thus, unless such habitat is destroyed or overly disturbed during development, these species will be affected less seriously by the possible reduction in prey than are the mammalian predators.

This overview section has presented a brief evaluation of the most obvious and/or likely impacts of Tract C-a oil shale development operations relative to the "study area" surrounding the tract. Long-term stack gas fumigation or mine dewatering can have the most widespread (local off-site) direct effects on the surrounding area. Other, more localized effects include area disturbance and salt water drift deposition. Over the whole study area, the net result of Tract C-a development will be a slight reduction in total productivity, the possibility of range condition deterioration, and increased disturbance due to greater human use of the area.

Tract C-a development will, by itself, have slight if any impact on Piceance Basin ecosystem functioning. It is not feasible to predict at present the effect of other oil shale developments on the ecosystem in the vicinity of Tract C-a, nor is it possible to presently analyze the cumulative impact of all oil shale developments planned for the Piceance Basin.

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SECTION 11

ENVIRONMENTAL MONITORING PROGRAM

CHAPTER 1
INTRODUCTION

Once the development of the prototype oil shale facility on Tract C-a commences, the project could continue for a number of years. Lease stipulations require the initiation of a monitoring program on the leased land ". . . six months prior to the commencement of the development operations." The monitoring program should continue until the " . . . Mining Supervisor has determined to his satisfaction that environmental conditions have been established after the termination of development operations which are consistent with the requirements of applicable Federal and State statutes and regulations . . ."

In response to these lease stipulations, monitoring programs have been developed for environmental studies on the basis of data taken during the first year of baseline data. These monitoring programs are designed to collect data which will reveal discrete changes in the environment which result from developmental activities. The monitoring programs discussed herein will be reviewed and possibly revised at the conclusion of the second year of baseline data collection effort if additional information indicates that this is desirable.

Monitoring programs are described for air quality, meteorology, terrestrial ecology, aquatic ecology, hydrology and revegetation studies. The air quality program is designed to provide a record on changes in air quality from baseline conditions. The meteorological monitoring program is designed to aid in identifying the impacts of plant operations. The terrestrial ecology monitoring program is designed to monitor the: effects of habitat disturbance and associated human activity on terrestrial ecosystems; areas dominated by unusually sensitive plant species; and success of habitat enhancement programs. The aquatic ecology monitoring program will be used to provide insight into the effectiveness of the RBOSP water quality control plan. The hydrology monitoring program will provide similar information about surface and sub-surface water and provide additional information on draw down of aquifers. The revegetation monitoring program is designed to determine the success of the revegetation program in establishing a self-sustaining vegetation community.

CHAPTER 2
AIR QUALITY

The air quality monitoring program will be conducted to provide a record of changes in air quality from baseline conditions; a continuing check on compliance with provisions of the lease and all applicable Federal, State and local environmental protection and pollution control requirements; and timely notice of detrimental effects and conditions requiring correction.

Both ambient air quality and selected emission sources will be monitored for concentrations of the various parameters such as sulfur dioxide (SO_2), hydrogen sulfide (H_2S), particulates, total hydrocarbons (THC), methane (CH_4), ozone (O_3), and nitrogen oxides (NO and NO_x).

2.1 AMBIENT MONITORING

Ambient air quality monitoring stations will be used to obtain data for determination of the following:

- Background ambient concentrations of air quality parameters unaffected by development operations.
- Maximum ambient concentrations of air quality parameters after the effects of Tract C-a operations.
- Performance of air pollution control devices.
- Ambient air quality in the neighborhood of biological test sites.

Monitoring stations will be located in the area of maximum ground level concentrations of parameters as predicted by modeling (see Section 9, Chapter 5) to demonstrate compliance with ambient air quality regulations. Background concentrations are determined in order to accurately establish the impact of Tract C-a operations at the point of maximum concentration and at the biological monitoring sites. Other stations will monitor emissions from mining and processed shale disposal operations.

A. Parameters - As stated above, SO_2, H_2S, THC, CH_4, O_3, NO, NO_x, and particulates will be monitored. The monitoring of SO_2, H_2S and particulates is required by the lease stipulations. THC and CH_4 will be monitored in order to determine non-methane hydrocarbon (NMHC) concentrations because background concentrations of NMHC exceeding Federal ambient air quality standards have been measured during the baseline data gathering program and Tract C-a operations are expected to add to these concentrations. Nitrogen oxides and O_3 will be monitored to evaluate actual impacts from plant development and the probability and extent of photochemical smog episodes, both of which are expected to be small since background concentrations measured on site and incremental concentrations of these compounds predicted by modeling (Section 9, Chapter 5) are low.

Carbon monoxide (CO) will not be monitored because background concentrations of this parameter as measured by baseline data gathering are approximately a factor of 10 below applicable standards, and modeling results show that plant emissions will not add significantly to the background concentration.

B. Sample Sites - Air quality parameters will be measured at five sites which are shown on Figure 11-2-1. Site 2 is an existing site used for baseline air quality/meteorological monitoring; this site will be used to measure background ambient concentrations of SO_2, H_2S, THC, CH_4, O_3, NO, NO_x, and particulates. Site 6 is located at the point where modeling studies have predicted maximum concentrations of SO_2, (Figure 9-5-23) and NMHC (Figure 9-5-32) during inversion conditions. Site 7 is located at the point of predicted maximum particulate concentration (Figure 9-5-29). Sites 3 and 5 will be used to detect any particulate contributions from the processed shale and overburden disposal pile to verify effectiveness of particulate control methods in these areas. In addition, Site 3 will monitor the effectiveness of particulate control methods in the mine. Table 11-2-1 lists the parameters measured at each site and the rationale for their locations. Figure 11-2-1 locates each site relative to Tract C-a. One additional site will monitor ambient air quality parameters near biological test sites. The location of this station has not yet been established. Operation of this site will be discontinued if and when the AOSS and RBOSP concur that it is no longer providing useful information to the overall monitoring program.

Table 11-2-1

PROPOSED AIR QUALITY PARAMETERS TO BE MONITORED

Site	Distance from Plant	Parameters	Justification
2	4 mi S	SO_2, H_2S, O_3, NO, NO_x, THC, CH_4, and particulates	Provide background levels of pollutants in ambient air approaching site from predominate wind direction.
3	2-1/2 mi SE	Particulates	Monitor dust concentrations from the mine and processed shale and overburden disposal areas.
5	4 mi E	Particulates	Monitor dust concentrations down wind from processed shale and overburden disposal site along nearest public access road.
6	2 mi WSW	SO_2, H_2S, O_3, NO, NO_x, THC, CH_4, and particulates	Provide measurement of regulated air quality parameters at the point of predicted maximum concentration for NMHC (1) and SO_2.(2)
7	1/2 mi W	Particulates	Provide measurement of ambient air particulates at point of predicted maximum concentration. (3)
8	Undetermined	SO_2, H_2S, O_3, NO, NO_x, THC CH_4 and particulates	Correlation of ambient air quality parameters with biological monitoring programs.

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(1) See Figure 9-5-32 for point of maximum short-term NMHC concentration.
(2) See Figure 9-5-23 for point of maximum short-term SO_2 concentration.
(3) See Figure 9-5-29 for point of maximum short-term particulate concentration.

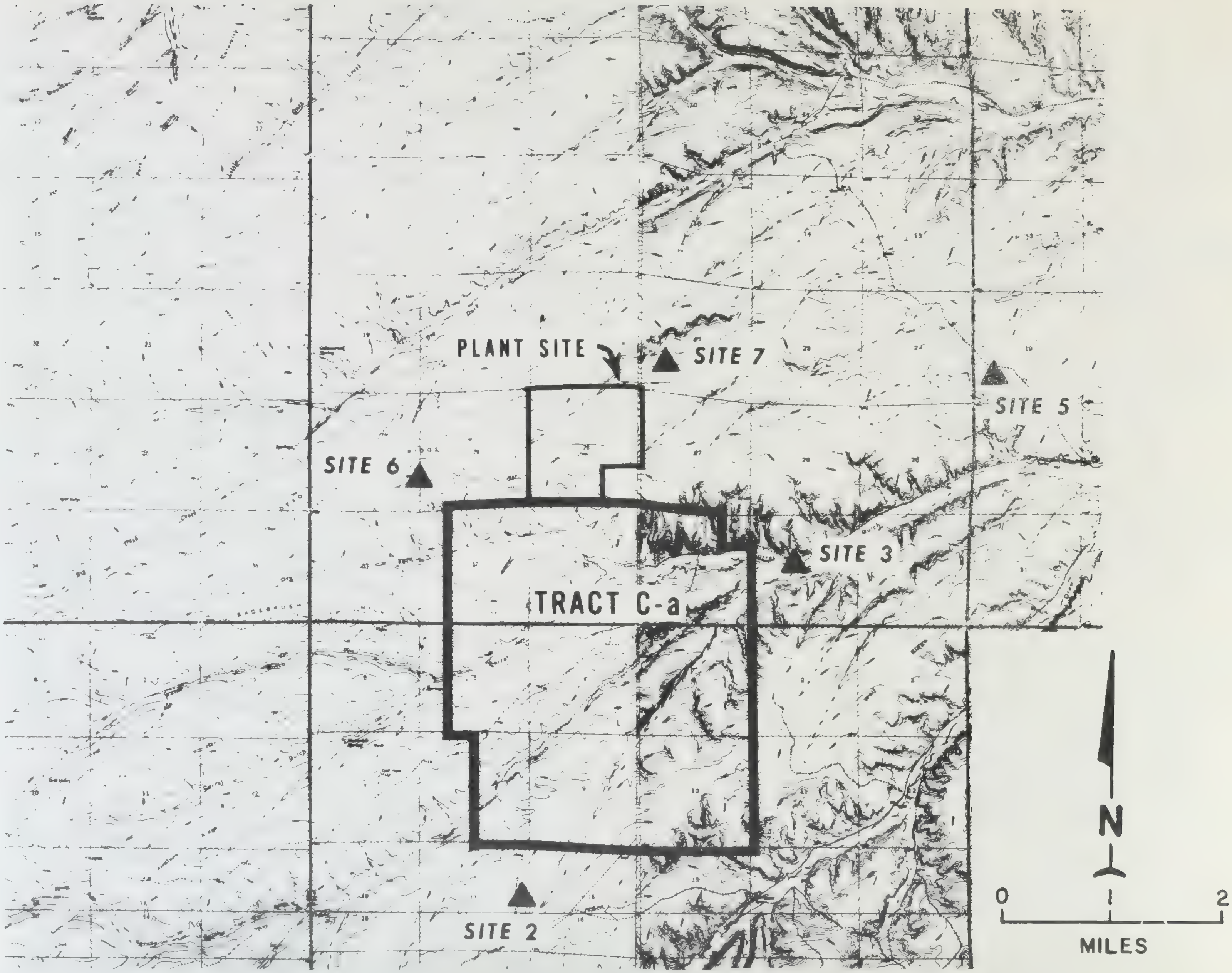

Figure 11-2-1

PROPOSED AMBIENT AIR MONITORING STATIONS

C. Measurement Frequency - Ambient air will be monitored continuously for the gaseous pollutants. Results of the monitoring will be compared with State and Federal ambient air standards to determine if and when short-term emergency mitigating procedures beyond the use of best available air pollution control equipment should be implemented to prevent ground-level concentrations of pollutants from exceeding ambient air standards. Comparisons will be made as needed to allow a timely response in the event of a build-up of pollutants in the atmosphere which might exceed Federal or State standards. Ambient air concentrations of particulates will be measured for an entire 24-hour period every six days and compared to Federal and State standards. Maintenance and calibration procedures will be continued as in the baseline programs to ensure accurate results.

2.2 SOURCE EMISSION MONITORING

Permits and approvals must be obtained prior to construction and operation under:

- Federal Significant Deterioration of Air Quality Regulations (U. S. Environmental Protection Agency, 1974);
- Colorado Air Quality Control Regulations (Regulation 3) (Colorado Air Pollution Control Commission, 1975).

The development of Tract C-a is a prototype oil shale development project and the specific requirements for source emission monitoring programs are not defined. The procedures for obtaining permits allow the agencies to require stack monitoring and stack sampling to ensure compliance with emission standards. The RBOSP source monitoring program will consider the pollution control devices employed, stability of operation, and the relative significance of each pollutant. Extensive discussions will be held with regulatory agencies as the engineering monitoring design progresses. Source monitoring and stack sampling that is needed to comply with the terms of permits and approvals will be included in the final design. Sampling ports and access facilities will be installed on each source which is controlled by air pollution control devices.

CHAPTER 3
METEOROLOGY

The meteorological monitoring program is designed to aid in identifying the impacts of plant operations; evaluating the results of mitigative procedures; and demonstrating that the Tract C-a operations are complying with all Federal, State, and local requirements.

3.1 METEOROLOGICAL MONITORING

A. Parameters - The meteorological parameters to be monitored are detailed in Table 11-3-1. This compliment of parameters will provide:

- Data to estimate the origin of pollutants and to provide associated meteorological conditions in the event that abnormal concentrations are measured;
- Data to identify plant site specific formation and persistence of adverse meteorological conditions (inversions);
- Data for fine tuning the dispersion models to existing conditions through correlations among measured meteorological conditions and air quality concentrations.

B. Sample Sites Identification - The meteorological monitoring program will measure meteorological parameters at three sites. Sites 1 and are shown in Figure 11-3-1. Site 8 will be a combination air quality/meteorological site located in the neighborhood of the biological test sites. The exact location has not yet been determined. The background air from the predominant wind direction will be measured at the 10-m level of Site 2. Sites 1 and 2 are existing sites, used during the baseline data gathering program. At valley sites 3 and 4, winds are governed almost entirely by channeling effects and drainage flows. This behavior will be well documented during the baseline data program. Meteorological data from these sites probably could not identify origins of measured pollutants; therefore Sites 3 and 4 will not be used as meteorological sites during the monitoring program.

Table 11-3-1

PROPOSED METEOROLOGICAL PARAMETERS TO BE MONITORED

Parameter	Site 1		Site 2	Site 8
	10-Meter Level	60-Meter Level	10-Meter Level	10-Meter Level
Solar Insolation	Yes(1)	No	No	No
Wind Speed	Yes	Yes	Yes	Yes
Wind Direction	Yes	Yes	Yes	Yes
Air Temperature	Yes	Yes	Yes	Yes
Temperature Difference (60-meter level - 10-meter level)	Yes	Yes	No	No
Relative Humidity	Yes	No	No	No
Wind Sigma	Yes	No	No	No
Precipitation	Yes(1)	No	Yes(1)	Yes(1)
Evaporation	Yes(1)	No	No	Yes
Snow Course	Yes(1)	No	No	No

(1) Measured below the 10-meter level.

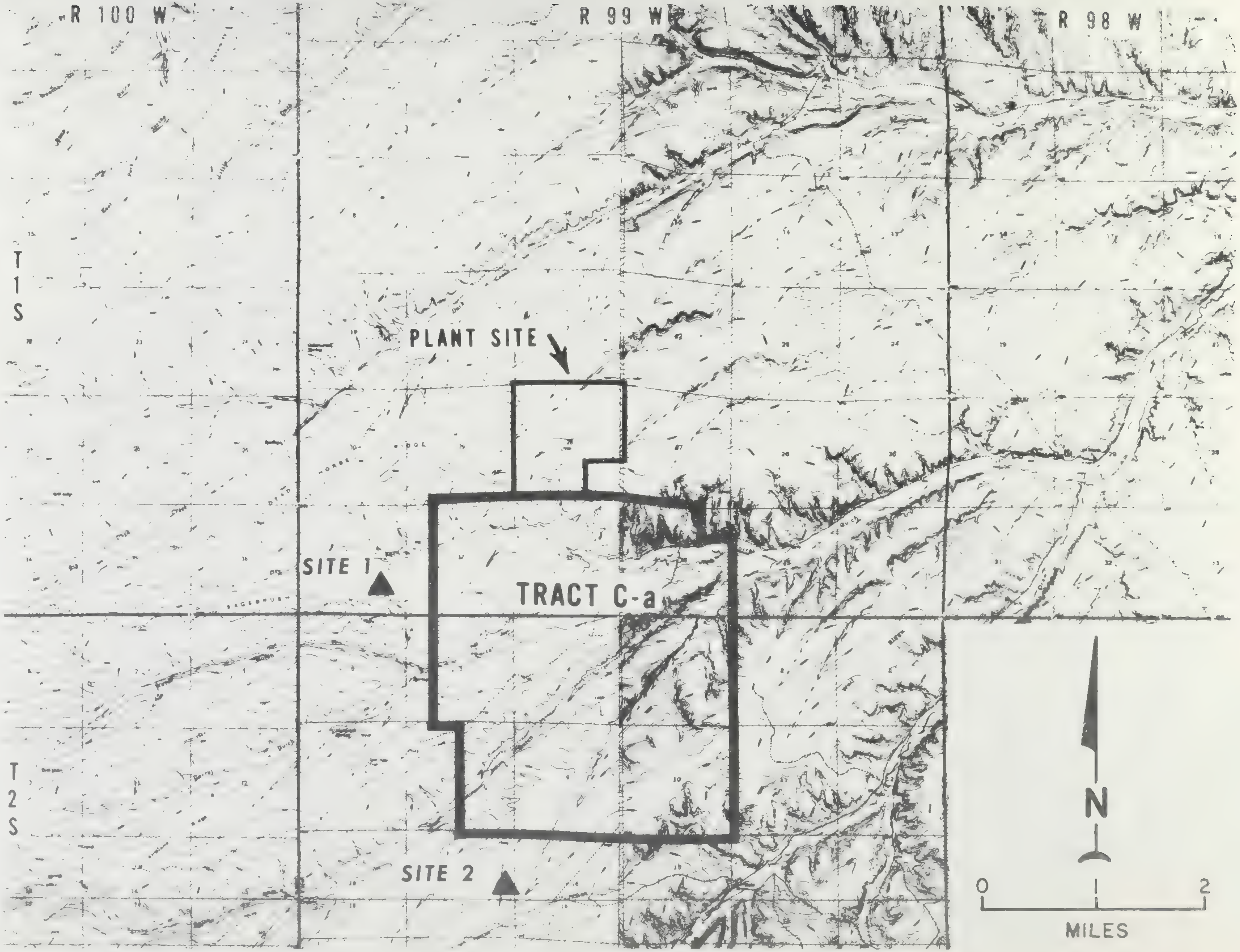

Figure 11-3-1

PROPOSED METEOROLOGICAL MONITORING STATIONS

Meteorological conditions representative of those affecting the dispersion of pollutants from the processing plant will be measured at the 10-meter and 60-meter levels at Site 1. This information can be correlated with upper air conditions based on data collected during the two-year baseline program.

C. Frequency - Meteorological results will be continuously available so that they can be compared to concentrations of gaseous pollutants. This data will be used to determine if mitigating procedures beyond the use of air pollution control equipment should be implemented to prevent exceeding ambient air standards.

CHAPTER 4
TERRESTRIAL ECOLOGY

4.1 INTRODUCTION

The basic objectives of the monitoring program are to determine the nature and extent of changes in the physical environment introduced by oil shale development and to relate these changes to their effect on living organisms existing within the impact area. To be effective the monitoring program must be based on quantitative measurements of the effects of development which can be statistically related to pre-development baseline conditions. To satisfy this objective a monitoring program has been designed which will:

- Measure the effects of habitat disturbance (due to mining operations and increased human activity) on the wildlife of the area
- Monitor the levels of gaseous and particulate emission, especially those most potentially harmful to the ecological balance of the system
- Monitor the status of sensitive plant species to determine effects of stack emissions on these species
- Measure the success of habitat enhancement programs enacted within the scope of the fish and wildlife management plan
- Verify the accuracy of impact assessments made from baseline data
- Identify unanticipated impacts.

The program design to be described in the following pages establishes eight primary monitoring sites, each of which is to be exposed to a different level of retort plant emissions, three control sites in nonaffected areas, three sites of habitat enhancement areas and a series of sites in sensitive vegetation communities. All primary monitoring sites will be established in pinyon-juniper communities with a shrub understory. This community type is emphasized because it is the predominant vegetation type found in the study area and accounts for 70% of the total cover and in addition, certain animal species are limited to pinyon-juniper vegetation.

Three control sites will be established in pinyon-juniper areas far enough off tract to prevent their being affected by oil shale development. These control sites will provide important information on natural variation in biological processes which are unrelated to man's oil shale activities. Such information can be used to determine the difference between natural and man-induced variations.

Sampling sites will also be established in each of the three habitat enhancement areas shown in Figure 11-4-1 to measure responses to enhancement against the control sites. This will indicate the effectiveness of enhancement procedures and the secondary effects of habitat manipulation on dynamic ecosystem processes.

Lastly, a series of secondary sampling sites will be established in areas containing minor vegetation communities (e.g., aspen-Douglas-fir) in order to assure that these communities are not affected by certain stack emissions. At these locations, only the sensitive species (as determined by field observations and literature) will be sampled to establish quantitative baselines necessary to identify pollution signatures on them during retort operations.

Concomitant with data collection is the need for an objective means of analyzing and presenting data. Therefore, accepted statistical techniques will be utilized wherever possible to analyze comparable data collected during various monitoring phases. This overall statistical design will test hypotheses in two steps.

In the first step, during the pre-operational monitoring phase, the following general null hypotheses may be tested (with specific hypotheses tailored to each experiment):

- H_o: No difference between monitoring and control sites under (pre-operational) conditions
- H_o: No difference between habitat enhancement and control sites under natural conditions
- H_o: No difference between seasons or between years at any given location under natural conditions

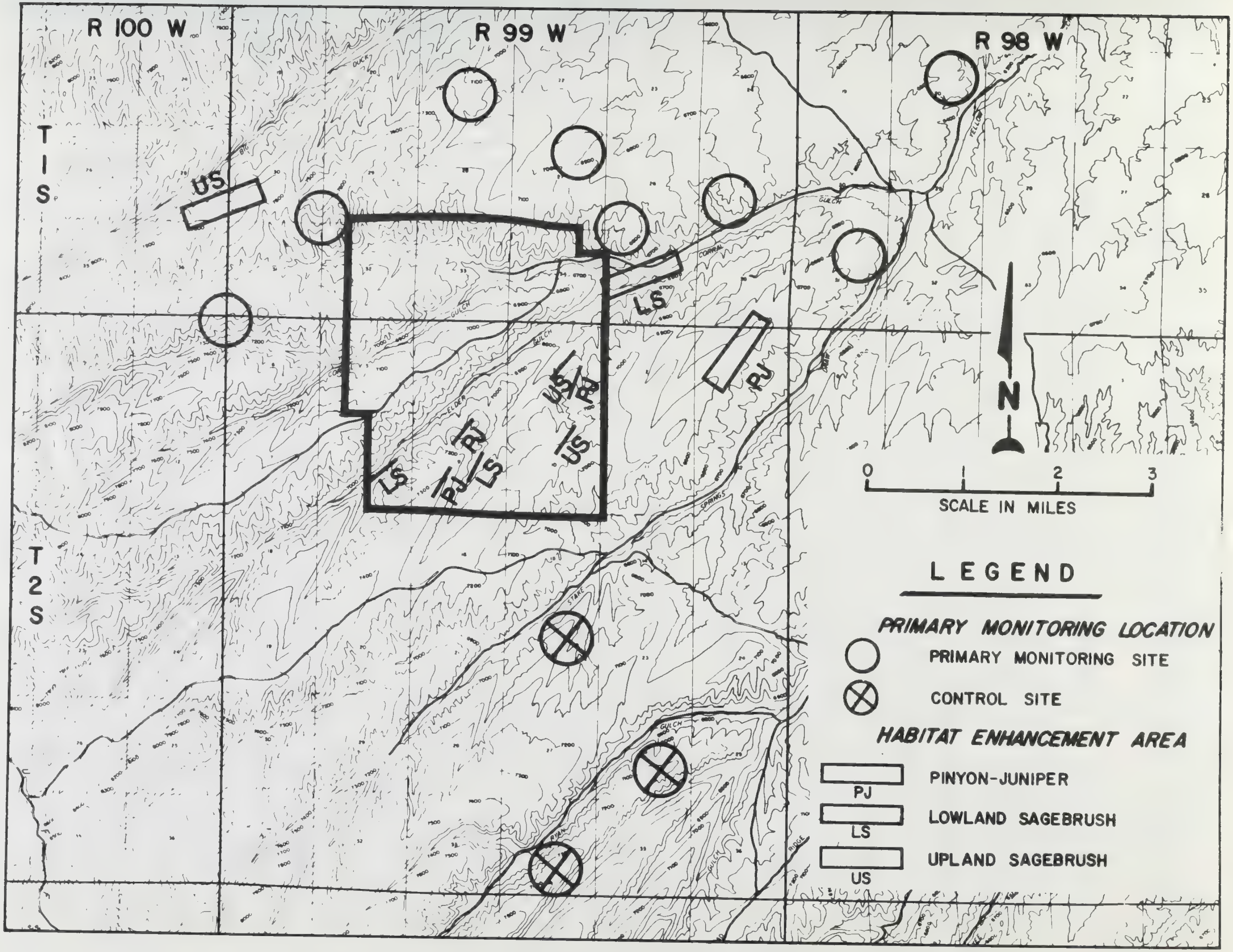

Figure 11-4-1

PRELIMINARY MONITORING & HABITAT ENHANCEMENT LOCATIONS

- H_0: No difference between monitoring stations or between control stations in a given season or year under natural conditions

The objective of sampling and statistical tests during the pre-operational phase is to obtain quantification of biological parameters expected to be most useful as indicators of response to oil shale-induced effects. The basic sample design calls for replications at each site for each of the measured parameters. For example, in sampling vegetation parameters, 10 random herbaceous quadrats per site are planned. A schematic diagram of the tabular form of a number of years of recorded data on herbaceous plant biomass, for example, is presented in Figure 11-4-2. Statistical analyses will be applied to these pre-operational monitoring samples to determine which of the sampled parameters are best suited to a scaled-down, long-term monitoring program and to estimate the most efficient sample sizes.

Data collected during the pre-operational monitoring phase will be statistically analyzed, primarily by analysis of variance procedures, in order to estimate variation between, as well as within, sampling sites. Detection and estimation of natural differences between sites is extremely important in estimating changes due to development. For example, pre-construction vegetation data such as that depicted in Figure 11-4-2 will be analyzed by a one-way analysis of variance. Such estimates of natural random variation from the pre-operational phase will be used in defining possible modifications of the sampling effort during the operational phase of monitoring.

Analysis of all data collected during the pre-operational phase, which will include data collected before and during construction (i.e., 1976 through 1979), will yield information on the environmental effects of construction by contrasting control and "affected" sites. Because of the sampling design (the sampling sites will remain the same throughout the study), the analysis of variance procedures will primarily be those for repeated-measurement designs. For example, if plant biomass investigations are selected for the long-term monitoring program, those data collected through 1979 (Figure 11-4-2) will be subjected to a two-way analysis of variance (that is, sites by years)

Site Type	Site Number	Quadrats Per Site	Sampling Periods						
			Preconstruction	Preoperational			Postoperational		
			1976	1977	1978	1979	1980	1981	1982
Treated	1	1 2 . . . 10							
	. . . 8	1 . . . 10							
Control	9	1 . . . 10							
	. . . 11	1 . . . 10							
Enhanced	12	1 . . . 10							
	. . . 14	1 . . . 10							
Special	15 . . x	1 . . x							

Figure 11-4-2

SAMPLE PLANT BIOMASS DATA SHEET

appropriate for repeated measures across time from each sampling quadrat. Comparisons of control and "affected" sites will have to be adjusted for possible natural differences between sites by analysis of covariance or other techniques.

Once the pre-operational data have been statistically analyzed and a long-term package of the "best" parameters selected, the second step (operational phase) of hypothesis testing will begin. The following types of null hypotheses will be tested during the operational phase of monitoring:

- H_0: No change in pre-operational differences established between primary and control sites as a result of plant operations
- H_0: No change in pre-operational differences established between habitat enhancement and control sites as a result of habitat manipulation
- H_0: No difference between pre-operational and operational conditions as a result of plant operations
- H_0: No correlation between site to site differences in biological parameters and emission gradients established by air quality samples.

The objective of sampling and statistical tests in the operational monitoring program is to permit detection, statistical verification, and assessment of the seriousness of any damages to local biota from plant operations, particularly stack emissions.

Data collected during the operational phase, together with the pre-operational data, will also be analyzed by analysis of variance and analysis of covariance procedures to assess the environmental effects of oil shale development. In addition, Chi square tests may be used on enumeration data as well as non-parametric procedures where appropriate. As in the case of the pre-operational data, the analyses will be those appropriate for repeated-measurement designs. Environmental effects of oil shale development will be estimated by comparing control and affected sites after adjustments have been made for pre-operational levels. Analysis of trends in affected sites during the post-operational period may also be used in predicting possible degradation of the environment.

To accurately assess and interpret the effects of plant operations upon ecosystems contained in Tract C-a and environs, it will be essential to understand the wide range of abiotic factors (e.g., weather, geology, hydrology, etc.) that influence the dynamics of the living components of the ecosystem. Optimum production, maintenance of stability and diversity, and other desirable properties of an ecosystem all depend upon a variety of these abiotic factors. Therefore, appropriate meteorological, air quality, and edaphic investigations must support the terrestrial monitoring effort.

During the operational phase, meteorological and air quality data will continue to be collected at three of the sampling locations. Data collected at these locations, together with information on stack emission velocity, will permit the projection of meteorological and air quality conditions for all sampling sites. In order to estimate the functional relationship of measured biotic parameters in treatment plots with abiotic parameters such as ambient pollution levels, statistical analyses will include multiple linear and non-linear regression analysis techniques.

Each analysis described above is "univariate" in that each variable is analyzed one at a time. Multivariate statistical procedures are currently being considered for possible use in the future.

At the relatively low pollution levels anticipated, the pre-disposing and subclinical effects on animals and plants may be impossible to detect in the absence of relevant information on population dynamics and biochemical or physiological information. To offset this problem, monitoring program elements will provide information at several levels of plant and animal organization. These program elements include:

- phytosociological investigations
- range condition and trend surveys
- primary producer biomass dynamics studies

- remote sensing
- invertebrate consumer dynamics investigations
- plant-disease relationship investigations
- vertebrate population dynamics studies
- trace metals analyses of selected plants and animals

Plant or animal species to be used for monitoring were selected on the basis of being commercially or recreationally valuable, critical to the structure and function of the ecosystem, and/or indicators of pollution stress (having known sensitivities to various pollutants). These species include the mule deer, sage grouse, deer mouse, least chipmunk, cottontail rabbit, raptors, western harvester ants, and several plant species.

The biological parameters and monitoring methodologies presented herein are tentative and subject to revision and modification as the need arises. An effective monitoring program should be sufficiently flexible to allow incorporation of updated information and new techniques as the program progresses, and to eliminate superfluous data collection. Therefore, this monitoring program will undergo constant review, particularly during the first few years of implementation to insure that the data and data-collecting methodologies utilized are the most effective possible.

A summary of the selected monitoring parameters and the anticipated associated statistical procedures are found in Table 11-4-1.

4.2 BIOLOGICAL PARAMETERS

A. Vegetation

1. Introduction - If there is a "most critical" trophic level in terrestrial ecosystems, it is the producer (green plant) level. By using the energy of sunlight to synthesize inorganic molecules into energy-rich "food" molecules, green plants nourish themselves and nearly all other organisms in the ecosystem. It follows that industrial influences, which are

Table 11-4-1

ENVISIONED STATISTICAL PROCEDURES TO BE APPLIED TO SELECTED MONITORING PARAMETERS

	Statistical Procedure										
Parameter	Analysis of Variance	Analysis of Covariance	Multivariate Analysis	Linear and/or non-linear Regression	Correlation	Chi-square	Multiple Range Tests	Time Series Analysis	Non-parametric Procedures	Shannon-Weaver Diversity Index	Students "t"
Calibration of Sites		X		X	X						
Control vs. Affected Sites	X		X			X			X		
Control vs. Enhanced Sites	X		X						X		
Seasonal Effects	X	X	X	X			X	X	X		
Effects between Years	X	X	X	X			X	X	X		
Biol. Effects vs. Emission Gradient		X		X	X						
Trace Metals in Biol. Matl. & Soils, Pre-operational & Operational	X	X	X	X	X						
Plant Diseases Pre-operational & Operational	X		X			X			X		
Litter Fauna Populations	X		X			X	X	X	X		
Litter Decomposition Rates Animal Population Changes Control vs. Sites		X		X	X						
Deer Population Changes Pre-operational vs. Operational						X			X		
Species Diversity Changes Control vs. Affected Sites										X	X
Soil Chemical Composition Control vs. Affected Sites	X		X	X	X		X				

potentially damaging to plant producers especially over wide areas, are the influences deserving the greatest attention. Major effects upon local vegetation are bound to have reverberations throughout the entire ecological system associated with that vegetation.

Thus, the vegetation component of the ecosystem is the most emphasized component in the monitoring program to be described. Moreover, although it is recognized that some areas will be affected by vegetation removal and unique habitats may be lost as a result of dewatering (Section 10-5), it is assumed that the greatest potential for area-wide damage to vegetation will result from long-range dispersal of effluents such as gaseous and particulate emissions from retort stacks and possibly from the concentration or dispersion of animals when habitat is lost. Therefore, the pre-operational monitoring program will focus on vegetation, particularly upon the kinds of vegetation and arrangements of sample plots which will most successfully reveal the effects of effluents and displaced animals on the vegetation.

A wide area around the proposed plant site will be studied to determine possible effects of stack emissions. Surveillance methods will include color infrared aerial photography, trace element analysis phytosociological and plant biomass studies, and grazing exclosure studies. Color infrared photography is a proven tool for detecting patterns of decreased vegetation vigor such as wide-area pollution damage. The level of resolution will be verified by a series of vegetation investigations within defined areas on the ground. At each primary monitoring and control site, ground level photography (color infrared and black and white) and chemical and trace element analyses of selected sensitive plant species will be used to document specific changes in vegetation condition caused by plant operation. Thus, patterns of decreased vegetation vigor identified by remote sensing will be investigated on the ground for insight into the species and causative factors involved.

Phytosociological studies and plant biomass productivity investigations will also be conducted at the primary monitoring and control sites to determine the effects of retort emissions on vegetation structure, diversity, and productivity. Similar studies will be executed at Wildlife Management Areas to determine the effects on vegetation of habitat enhancement procedures. Another series of investigations will be aimed at establishing quantitative baseline values for visible symptoms frequently associated with sulfur dioxide exposure in plant species of known sensitivity.

The grazing exclosure established on Tract C-a will be sampled at the following intervals in order to establish the trend of vegetation change within the exclosure: sampled in years 1,2,3,5, and 8 after establishment of grazing exclosures and at 5-year intervals thereafter. Information obtained from the grazing exclosures will be used to determine the relative importance of individual plant species to wildlife and domestic livestock. These determinations may establish priorities for selection of plant species to use in revegetation efforts and will provide a means for improving carrying capacity evaluations and for facilitating land management decisions. Finally, range, browse, and soil condition and trend surveys will be conducted at intervals similar to the grazing exclosure study in order to detect rangeland changes resulting from possible gaseous emissions, management procedures, and altered large mammal distribution patterns.

2. Methods and Materials

a. Remote Sensing - A key element of the vegetation monitoring program for Tract C-a will be the application of color infrared aerial photography (Osberg, et al. 1975) to detect the effects of air pollution.

Repetitive infrared photography of a particular ground area is an established technique (Colwell, 1963) for detecting both natural and man-induced changes in vegetation (Genderen, 1974; Pollanschuetz, 1968; Zealear, Heller, Norick, and Wilkes, 1971) and has been applied in the assessment of terrestrial effects of air pollution from industrial facilities (Genderen, 1974; Pollanschuetz, 1968; Zealear, et al. 1971). In some applications, color infrared photographs detect plant injury from air pollutants prior to visual plant symptoms (Bravo, 1972) or reveal non-visible injury that may be associated with decreased growth and yields (Pollanschuetz, 1968).

To determine if changes in vegetation vigor occur in the vicinity of Tract C-a as a result of retort emissions, an aerial flight designed to provide color infrared imagery will be conducted once every 3 years. The initial flight was conducted during the first year of baseline investigations. All photography will occur during the peak growing season which generally occurs between mid-June and mid-July. As vegetation is considered most sensitive to pollutants during this period (Brandt and Heck, 1968), any effects from processing emissions should be more apparent.

Areas depicted in color infrared imagery which demonstrate a reduction in vegetation vigor will be mapped for subsequent ground examination in addition to the normal on-site activities. Ambient levels of pollutants as determined by air quality monitoring stations, close visual examination, and possibly chemical and trace element analyses will be used to ascertain if the reduced vigor can be attributed to retort emissions.

b. Specific Site Studies

1) Primary Monitoring and Control Sites

a) Phytosociology - To evaluate possible changes in vegetation community composition and structure as a result of possible chronic air pollution, a permanent vegetation transect will be established at each of the primary monitoring and control sites.

As in the first year of study, a modification of the line-strip technique as described by Woodin and Lindsey (1954), Lindsey (1955), and Potter (1957) will be used during the phytosociological investigations. Investigations will be conducted at the height of the growing season, approximately mid-June to mid-July.

1) Tree and Shrub Strata - A taut 30-m (98 ft.) tape defining the centerline of the transect will be used to determine the foliage intercept distance along the line for each of the 100-m (328 ft.) transects. In addition to recording foliage intercept, a count will be made of shrubs,

seedlings, and saplings of each species occurring within approximately 3 m (10 ft.) on either side of the tape measure. The 3-m (10-ft.) distance from the tape will be measured at the start of each transect and will be repeatedly measured when distances of individual shrubs or trees are in doubt. Density values for shrubs and for seedlings and saplings of tree species will be determined from this census. Census data will be collected and recorded by 20-m (65.6 ft.) segments of the transect, effectively making a series of five quadrats, approximately 20 x 6 m (19.7 ft.). This series of quadrats will serve as the basis for frequency values for the shrub and tree strata.

For mature trees located in each quadrat, the diameters will be recorded in centimeters. The enumeration of these recorded entries will serve in determination of density in the mature tree class. Trunk diameters will be recorded for trees over 7.6 cm (3 in.). The trunk diameters will later be converted to basal area values. Size-class distribution will also be derived from the recorded measurements of trunk diameters. Tree trunk diameters will be measured to the nearest centimeter. Due to the low branching habits of both pinyon and juniper, measurement will be made at a height of 0.5 m (1.64 ft.) (Barger and Folliott, 1972) unless the trunk is forked below that level, in which case it will be measured just below fork swell and above basal fluting.

For all flowering plants (Angiospermae), a phenology code will be recorded to indicate the stage of development for each species observed in a given sampling period: (1) emergent, (2) vegetative, (3) initiation of flowering, (4) flowers fully developed, (5) initiation of fruits, (6) fruits fully developed, (7) dehiscence or dispersal of seeds, (8) death of dormancy of plant and other factors where deemed applicable. Any unusual anomoly or pathology will also be noted.

2) Herbaceous Stratum - Herbaceous cover values will be estimated within a 0.5 x 1-m (1.64 x 3.28-ft.) rectangular metal frame quadrat. The long axis of the quadrat will be placed parallel to and on the right side of the centerline tape and centered at 10-m (33 ft.) intervals.

Each species will be identified and noted. Plants not identifiable to the species level will be collected at a nearby location and assigned a code number corresponding to the entry on the data sheet. The ground cover of each species will be calculated to the nearest 1%. When it is calculated that the total cover or a species cover value is less than 1% (e.g., one blade of grass), it will be indicated by a "T" (trace) on the field data sheet. Frequency values will be derived from the recorded occurrence of each species in the ten, 0.5 x 1-m (1.6 x 3 ft.) quadrats sampled along each transect. Density, or the number of individuals of species occurring in each quadrat, will also be recorded.

b) Color Infrared Photography - Color infrared photographs will be taken of herbaceous, shrub, and tree species on the phytosociological transects to assess changes in species composition, cover, and condition that might result from air pollution stress.

1) Herbaceous Stratum - During each phytosociological sampling period, 35 m color infrared photographs will be taken for herbaceous quadrats. Within each of the ten, 0.5 x 1-m (1.6 x 3 ft.) herbaceous plots on each transect, tags will be placed behind each species to facilitate plant identification from photographs. A rough chart of the plot will be prepared to show locations and identification of the various species. The plot will then be photographed from a vertical position directly above the center of the plot. All photographs will be taken between the hours of 9000-1100 or 1300-1500 Rocky Mountain Standard Time to obtain uniform lighting conditions.

Enlargements of permanent plot photographs will be interpreted by preparing species overlays and will be used to assess oil shale-induced changes in species composition and cover. Vegetative condition will be qualitatively, and where possible quantitatively, determined by description of the reflectance qualities indicated by the color-infrared imagery of each species.

2) Tree and Shrub Stratum - Trees and shrub within each 6 x 100-m (19 x 328 ft.) transect will be marked and photographed during remote sensing flights (Section 4.2.A.2.a). Corners of the transect will be indicated by visible markers. Vegetation condition will be determined in a similar

manner as that utilized for the herbaceous stratum.

c) Biomass Productivity Studies - An electronic capacitance meter will be used to nondestructively estimate above-ground biomass for herbaceous and shrub species within each transect during each phytosociological investigation. The capacitance meter is expected to provide a sensitive and efficient means of monitoring vegetative responses to pollutant emissions as reflected in reduced productivity (Neal, et al. 1976). The herbage meter is calibrated each morning by comparing capacitance readings and actual clipping weights, and compared by regression techniques. Recalibration from day to day usually requires only a slight readjustment after the meter has been initially adjusted. Recalibration involves reading the meter, then clipping and weighing the plot and, finally, adjusting the meter accordingly. This is repeated until clipped weights and capacitance readings are consistently comparable.

1) The Grass-Forb Stratum - Biomass of herbaceous species will be determined within each 1 x 0.5 m (3 x 1.6 ft.) herbaceous quadrat at each phytosociological transect. To eliminate sampling bias, biomass readings will be taken from a standard, permanently marked location for each quadrat. To reduce variance in herbaceous biomass due to grazing, each quadrat will be protected from ungulates with meshed wire cones.

2) The Shrub Stratum - The closest predominant shrub to each herbaceous phytosociological quadrat will be selected for determing the effects of plant operation on shrub productivity. Productivity studies in this stratum will be two-phased. In Phase I, individual shrubs of the selected species will be measured by black and white photography from permanently marked reference points. Selected shrubs will be permanently tagged and photographed, at the height of the growing season each year, against a gridded, white background. The second phase will involve taking biomass readings with the capacitance meter from permanent reference points.

d) Chemical and Trace Element Analysis - Vegetation chemical and trace element analysis methods are described in Section 4.3.D.

e) Evaluation of Salt Drift Effects on Vegetation - Salt drift from cooling towers may affect local vegetation through direct impingement on leaf surfaces or effects on soil salinity; both avenues of effects may ultimately produce the same results -- a change in species composition or, in extreme cases, a complete loss of plant cover within affected areas. In order to determine whether the effects of salt drift have altered plant species composition and cover, results of phytosociological studies will be compared with soil survey chemical analysis (Section 4.3.D). A correlation between monitoring sites of increased soil salinity associated with phytosociological changes (decreased cover and introduction of halophytic plants can be used as an indication of the effects of salt spray on plant community composition.

1) Habitat Enhancement Areas - To assess the effects of habitat manipulation on vegetation structure, diversity, and productivity, phytosociological and biomass-productivity investigations will be employed at the habitat enhancement areas. The sampling methods outlined above for primary monitoring and control sites will be used to collect phytosociological and biomass-productivity data.

2) Areas Dominated by Species Sensitive to Air Pollutants - The methods described below are aimed at establishing quantitative baseline values for visible symptoms frequently associated with exposure to sulfur dioxide and other gaseous emissions in plant species of known sensitivity.

Although Douglas-fir and aspen are known to be highly sensitive to fluoride (Treshow and Pack, 1970), air pollution effects on vegetation in the vicinity of Tract C-a are most likely to result from sulfur dioxide emissions. Symptomatology would likely reveal whether SO_2 (interveinal spotting) was the primary cause of observed damages. Mountain mahogany, aspen, and Douglas-fir, all of which occur primarily to the west of the tract, are known to be highly sensitive to sulfur dioxide (Lamb, 1972; Treshow, 1970; Lowan et al., 1972; Hill et al., 1974).

During the pre-operational monitoring program, 10 individuals each of mountain mahogany, aspen, and Douglas-fir communities, respectively will be selected. The selected individuals will be permanently marked and photographed using color infrared film. Photographs will be taken from a permanently marked reference point. For each plant, 100 leaves (or needles) will be randomly selected and examined for extant chlorotic or necrotic symptoms that are characteristic of air pollution stress. Chlorotic injury is distinguished by a gradual yellowing but is also indicated by a blotchy to stippled effect. Necrotic injury is identified by tipburn, banding, or basal burn, with the injured areas taking on reddish-brown color (Brandt and Heck, 1968). The percent area of damage will be qualitatively measured.

If during plant operations air quality data or remote sensing investigations indicate possible damage to vegetation species as a result of processing emissions, the marked individuals of each of these species will be re-examined by the same methods to determine if an increase in chlorotic or necrotic symptoms has occurred.

3) Grazing Exclosure - The grazing exclosure established in the southwest quarter of Tract C-a will be sampled in years 1,2,3,5, and 8 after establishment of the grazing exclosure and at 5-year intervals thereafter to determine the relative importance of individual plant species to wildlife and domestic and feral livestock. These determinations may establish priorities for selection of plant species to use in revegetation efforts and will provide a means for improving carrying capacity evaluations and for facilitating land management decisions.

Quantitative and qualitative study techniques and photoplots as described in the Second Annual Report for Terrestrial Baseline Investigations for RBOSP (February 1976) will be utilized to measure the response of the plant community within the exclosure to a release from foraging animals. All techniques will focus on incremental forage production resulting from the degree or quality of protection being afforded.

4) Vegetation and Soil Condition and Trend - Range, browse, and soil condition and trend surveys will be continued at intervals concurrent

with the grazing exclosure study to document rangeland changes resulting from possible gaseous emissions, management procedures, and altered ungulate distribution patterns.

The procedures used to establish vegetation and soil condition and trend are consistent with common range analysis practices as described in detail in the United States Department of Agriculture Forest Service Handbook 2209.21R3 (1970) and the Second Annual Report for Terrestrial Baseline Investigations for RBOSP. Maps on which vegetation types are delineated by remote-sensing techniques will be used to locate field sampling locations.

Each delineated vegetation type estimated to be greater than 16 ha (40 A) but smaller than one-half section (128 ha) in size will be sampled by means of one paced transect. In larger types, transects will be placed at an approximate rate of one per one-half section, longitudinal to and centered within the shape of the type. A total of 137 transects, each 400 paces in length, will be established. Sampling points along a transect will be located at four-step intervals for grass-forb data collection (100 sampling points) and at 16-step intervals for brose data collection (25 sampling points).

B. Invertebrates

1. Introduction - The objectives of the invertebrate monitoring program are to assess the effects of oil shale development on the populations of important invertebrate groups and the effects of habitat manipulation (e.g., Wildlife Management Plan) on these same groups.

It is accepted by many ecologists that invertebrates form the largest consumer group in most natural habitats. However, the importance of invertebrates to the ecosystem is not limited to their role as primary consumers. Invertebrates also play an active role in nutrient recycling, pest control, and plant reproduction. They also produce products useful to man (e.g., honey) and are important food for many birds, mammals, reptiles, amphibians, and other invertebrates.

Extensive sampling of invertebrates in the vicinity of Tract C-a through the spring and summer of 1975 revealed a number of groups important to the function of Piceance Basin ecosystem (Section 3-7). Four of these important groups (litter and flying invertebrates, western harvester ants, and plant associated invertebrates) are reviewed here in more detail with reference to their usefulness in the terrestrial monitoring program.

a. Litter Fauna - Invertebrates inhabiting organic litter on the ground surface, primarily springtails (Collembola) and mites (Acari), are predominate in the Tract C-a invertebrate fauna. Within the invertebrate litter fauna there is a complex food web which includes saprovores, herbivores, omnivores, predators, and fungus feeders (Dodd, et al., 1975).

A healthy litter fauna is important in the role of plant and animal litter decomposition. This decomposition is critical to ecosystem dynamics as the mechanism by which nutrients are recycled back to green plants for additional productivity. The role of invertebrate fauna is especially critical in arid climates where litter decomposition is a relatively slow process. Thus, major effects of plant operations upon litter invertebrates could have serious ecological repercussions. Potentially, a variety of responses by the pinyon litter fauna to plant operations could occur. There may be decreased litter activity due to soil accumulation of particulate matter and toxic substances emanating from processing stacks. Pradhan (1959) discusses invertebrate integument thickness as an adaptive measure to prevent loss of moisture and to control gaseous exchange. Invertebrates without the hard integument may be more subject to desiccation and direct absorption of foreign liquids and gases. As a protective behavior pattern, many of these groups restrict their activities to the litter layer but emerge when high moisture, high humidity, and moderate temperature conditions exist, usually during the early summer morning hours on and near Tract C-a. This time period is also the one in which higher emission concentrations are expected to coincide with the almost daily occurrence of temperature inversions (Section 3-6). Exposure of the soft-bodied invertebrate litter fauna to emissions during these periods could reduce their abundance and diversity. Hard-bodied litter invertebrates such as Orbatid mites may not be as much affected by emissions under these conditions as the soft-bodied invertebrates. The litter fauna is probably more sensitive as a group to the toxic agents in emissions than any other invertebrate group.

In research on the relative sensitivity of different insect groups to insecticides, it has been demonstrated that the invertebrate litter fauna may be adversely affected at much lower dosages than the herbivore fauna at which a spraying program was aimed.

b. Flying Invertebrates - Active flying Hymenoptera, composed primarily of a variety of bee and parasitic wasp families, comprised a substantial proportion of the invertebrate fauna at all sites sampled during baseline investigations.

A wide variety of effects resulting from air pollution have been demonstrated for Hymenopterans. Body hairs of bees collect pollen and insulate the bee from extreme heat and cold (Pradhan, 1959). In addition, body hairs protect the openings of the tracheal system (spiracles) from the entrance of particulate matter. However, Connell and Glynne-Jones (1952) found that particles less than 5 μ can still enter the tracheal system. Relatively small amounts in the tracheal system can negatively influence oxygen intake, thereby reducing activity or increasing the amount of energy required to maintain a given level of activity.

Hillmann (1972) found that honeybees which were chronically exposed to low levels of SO_2 demonstrated a variety of adverse effects. Worker bee longevity and honey production decreased substantially in fumigated hives. At SO_2 levels around 1.5 ppm, the normal flight activity and colony weight increases over the summer were reduced. This apparent suppression of normal colony development was the same regardless of the SO_2 level (above 1.5 ppm). Brood measurements showed that the quantity of brood decreased linearly with increased SO_2 concentrations. Erratic queen laying behavior also occurred as evidenced by the changes in brood pattern. Additional evidence of the effects of SO_2 was found in the fact that pollen essential in brood production was collected in decreasing amounts with increased SO_2 fumigation. This may be related to decreased flight activity in bees from fumigated hives.

Hillmann (1972) found a significantly larger aphid population in areas of SO_2 emissions than in control areas in his research. The same results were obtained by Darley (1966) for areas of high cement kiln dust effluent. Darley (1966) postulated that the ability of the aphid parasite complex (mainly Hymenopterans) to control the aphid population was reduced because the toxic emissions probably reduced the numbers of parasites. Both Hillmann (1972) and Darley (1966) indicated that there may be variation in the susceptability of different insect groups to effluent sources.

c. Western Harvester Ants - Another group of Hymenopterans, the ant family (Formicidae), was the most abundant invertebrate group captured in all habitat types during the first year of study. Ants utilize a variety of food sources but probably exert their greatest influence on the ecosystem as herbivores. Harvester ants are common to the study area and are known to be sensitive to SO_2 fumigation. In addition, the vigor of harvester ant colonies may be affected by accumulations of airborne toxic particulates carried into the nest on seeds, vegetative material, and litter.

d. Plant-Associated Invertebrates - The tree stratum in the various vegetation types on Tract C-a provides a variety of micro-habitats for many different vertebrates and invertebrates in addition to forming one of the largest repositories of photosynthetic energy stored in the form of plant tissues (biomass).

The health of a tree determines its ability to withstand insect damage (Chamberlin, 1952; Graham and Knight, 1965). For example, a healthy tree can withstand more defoliation or boring by insects than an unhealthy or weakened tree. The healthy tree is usually able to actively fight bark beetle attack through "pitching out" of the beetles by clogging their tunnels with resin. In this manner, a "balance" is achieved between the amount of insect attack and the tree's ability to resist such attack. Healthy trees are usually able to prevent excessive damage. Any reduction in the vigor of the tree which can be caused by air pollutants such as SO_2 (see Section 10-5) may result in increased insect attack, resulting in further deterioration and ultimately in death of the tree.

There is a possibility that if pinyon pine is weakened by exposure to gaseous emissions, then increases in insect attack and severe damage to trees could occur. Scheffer and Hedgcock (1955) found that in areas where concentrations of SO_2 ranged from 0.11 to 0.50 ppm, there was an increase in attack and death of older Douglas-fir by *Dendroctonus* and *Ips* beetles. Stark and Cobb (1969) found that ponderosa pine in California, weakened by smog components, was very susceptable to damage by root disease and bark beetle attacks. In another study Stark, et al. (1968) found that at very low levels of ozone there was a definite relationship between tree health (as indicated by extent of chlorosis) and frequency of *Dendroctonus* sp. attack on ponderosa pine.

2. Methods and Materials

a. Population Dynamics

1) Litter Fauna - Pinyon pine litter will be quantitatively sampled for invertebrates at each primary monitoring, control, and habitat enhancement site where pinyon pine is found. Sampling will take place in May, July, and September. To reduce natural variation in litter population levels, samples will be taken from the area of maximum litter accumulation which is usually on the north side of the tree within 1 m (3.28 ft.) of the trunk.

The litter decomposition and litter fauna will be monitored using litter bags as described in Crossley and Hoglund (1962). Each monitoring and control site shall have 24 litter bags containing a known quantity of mixed litter. Every 4 months a litter bag shall be removed from each of the stations, Berlese'd and weighed. The weights shall be recorded and decomposition rates calculated. If there is a significant shift (as determined by analysis of covariance technique) in the decomposition rates, then an investigation shall be conducted for the cause.

The invertebrates obtained from the Berlese extraction shall be classified and enumerated. This information shall be used for sudden shifts in represented taxa and species diversity; any large change in these categories will be investigated.

Each Berlese funnel consists of a sheet metal cylinder 40.6-cm long and 35.5-cm in diameter, with a cone of equal diameter and 25.4-cm long attached to the lower end. A jar lid is attached to an opening at the apex of the cone to which sample collection jars partially filled with a 30% alcohol solution are attached. Samples are placed on two grids set inside the cylinder. The remaining open end of the cylinder is covered with a cone 5.2-cm high containing a light bulb socket. The sample is placed in the refrigerator prior to being put in the Berlese to decrease invertebrate activity. It is then dumped onto the grid in the cylinder; the top cone, containing an illuminated 60-watt bulb, is then placed over the cylinder. The heat from the bulb causes the debris to become hot and dry, whereupon most invertebrates tend to move downward to escape, eventually falling into the preservative in the jar at the bottom of the funnel.

2) Flying Invertebrates - Population studies of actively flying Hymenoptera will be conducted using Malaise traps. Sampling will be conducted in May, July, and September at each of the primary monitoring, control, and habitat enhancement sites.

One trap as described by Townes (1972) will be placed at each of the sampling sites to capture mobile airborne species. The trap consists of a tent made of dacron netting(10 meshes/cm; 25 meshes/in) which is open on two sides and divided in the middle. A wire fence consisting of four 1.4-m posts and two strands of No. 9 gauge wire will be put up around each trap to prevent interference from cattle and deer.

Invertebrates which fly into the trap hit the dividing screen and then begin to crawl upward along the screen to the highest point of the tent where they enter a jar containing a preservative. The trap is designed for flying groups such as Diptera and Hymenoptera, which exhibit a characteristic upward crawling movement when trapped. Other groups, such as Homoptera, Hemiptera, and Coleoptera often drop off the screen and escape by crawling or hopping out.

The Malaise traps will be opened for 10 days each sampling period. Traps will be checked and insects removed on a daily basis. Samples are labelled, logged into the record book, and transported to the laboratory for identification and enumeration.

3) Western Harvester Ants - An overview of patterns in the density and distribution of harvester ant colonies will be obtained from remote sensing photographs in the pre-operational monitoring phase period. If other evidence indicates that some areas are receiving abnormally high stack emissions, comparable photographs obtained during plant operations will be carefully evaluated for correlated changes in ant colony distribution.

At the ground level, colony vigor tests will be performed in five randomly selected colonies at each site. Vigor tests will be conducted on the same colonies in each sampling period. The methods used will be one developed by Race (1964) and modified by Rogers (1972). The method consists of grinding ants in a blender, placing a drop of the resulting liquid near the colony entrance, and photographing the resulting response to the liquid. The camera will always be held 1.2 m directly above the disc so that the picture will always cover the same surface area, and the picture will be taken one minute after application of the liquid in all samples. To reduce variation in ant response due to environmental conditions, ground temperature, cloud cover, and time of day will be duplicated as much as possible for each colony photographed during each sampling period. A count of the ants responding to the liquid will give a vigor rating which can be compared to other samples, sites, and data from other sampling periods.

b. Plant Associated Invertebrates - Pinyon pine will be sampled at each of the primary monitoring and control sites. Ten trees at each site will be randomly selected for sampling. After trees are selected and marked at each site, 50-100 sweep samples of the foliage of trees not used in sampling will be taken. These samples will form a source of material for collection as well as a means of familiarizing the field technician with the types of insects to look for during visual observations. Five types of quantitative sampling designed to reflect the number of organisms per unit of food supply (Graham and Knight, 1965) will be conducted on pinyon pine at each site.

- Needle miners - During May, July, and September, 100 needles will be inspected from each tree to determine if a leaf-mining species is inside or has been inside. Branches to be searched will be picked at random and a maximum of 10 needles will be examined for any one branch.
- Cone feeders - Also during each sampling period, 10 green cones will be randomly selected from each tree and brought to the lab for dissection. The extent of insect damage will be recorded and the insect larvae present preserved. Some larvae will be reared by using small nylon mesh bags tied to branches where they occur. This is necessary to determine the insect species causing the damage. If evidence of damage is found, net bags will be tied over a number of cones to obtain adult specimens for identification purposes.
- Seed feeders - One-hundred seeds will be randomly obtained for dissection from each tree during September. Evidence of insect damage will be recorded. Insects found in the seeds will be preserved for a specimen record. In addition, some seeds will be returned to the lab, left in the refrigerator, and then allowed to stand to obtain adult forms of any seed parasites present.
- Branch sampling - During May, July, and September, 10 branches at breast height of each tree will be examined in detail for defoliators, sap suckers, scales, and other herbivorous insects. Insects seen will be identified and counted, and specimens retained for more complete identification.
- Borers - During September, larvae will be quantified by examining a 15-cm^2 area of bark of each tree and counting exit holes. In addition, a permit will be obtained from the BLM to remove two trees in September for emergence trap studies. A dead tree and a standing tree which shows obvious signs of insect infestation will be selected.

Trees will be sectioned and the sections grouped according to whether they came from the top, middle, or bottom of the tree. All sections will be transported to the lab and placed in emergence traps to obtain species for identification and estimation of sequence of emergence of beetles.

C. Vertebrates

1. Introduction - The vertebrate monitoring program is designed to determine the effectiveness of habitat enhancement procedures for management species (e.g., mule deer), assess the secondary effects of habitat enhancement on other components of the ecosystem and, most importantly, identify impacts of oil shale development on vertebrate community structure and dynamics. The effects of habitat disturbance or manipulation and increased human activity will mainly at the population level of vertebrate organization, resulting in identified changes in dispersion and relative abundance of the more mobile species (e.g., mule deer). The effects of retort plant emissions, however, may be more subtle. Relatively long-term, chronic pollution challenge could kindle complex changes in ecosystem dynamics.

In the attempt to relate the environmental impact of specific oil shale development action (e.g., habitat disturbances and retort emissions) to significant components and processes of the ecosystem, species identified as "important" during baseline investigation will receive the major focus of the vertebrate monitoring program. "Important" species were selected largely on the basis of criteria presented by the Nuclear Regulatory Commission (1975) and include the economically important mule deer and sage grouse and the ecologically important deer mouse, least chipmunk, and raptorial birds in general.

2. Methods and Materials

a. Small Mammals - To identify changes that occur in small mammal population structure and/or dynamics as a function of possible processing emissions and/or habitat disturbance, a live-trapping program will be conducted at each of the primary monitoring, control, and habitat enhancement sites. To coincide with periods of increased small mammal activity and to provide reliable data on population size, survivability, immigration, recruitment, productivity, and other population parameters, sampling will be conducted during May, July, and September. Within each sampling site, two parallel lines of live traps will be established 15 m (50 ft.) apart. There will be 20 trap stations 15 m (50 ft.) apart with two "Sherman" type live traps at each station.

Trap stations will be prebaited for 2 nights prior to trapping. Baiting, and prebaiting, will be with a mixture of peanut butter, rolled oats and cracked corn. Traps will be run for 3 consecutive days during each of the sampling periods. Traps will be checked twice daily, once in the early morning and once in the late afternoon. To minimize desiccation and death of trapped animals from solar radiation, cardboard will be positioned over each trap in a Λ shape to provide shade for captured animals. A wad of dacron, wool, or cotton batting is placed at the back of each trap to provide further insulation.

Traps will be reset and rebaited as necessary. All animals captured will be distinctively marked by unique toe-clipping combinations and released. For each animal captured, the species, sex, age-class, weight. reproductive status, general physical condition, capture location, and animal identification number will be recorded on a standard trapping form. Weights will be determined to 1.0-gm accuracy using a Pesola calibrated spring scale.

Although the live-trapping method defined above marks a deviation from baseline methodology, large grids are not necessary to determine the required population parameters for monitoring. The trapping design as presented here will produce results of similar efficacy to those of the grids of the baseline study.

b. Lagomorphs - To assess the effectiveness of lagomorph habitat enhancement procedures, a road transect 48 km (30 mi.) will be established traversing major habitat types including the enhancement areas. These road transect surveys will be in conjunction with the owl transect program.

c. Avifauna

1) Songbirds - Species, population size, and other population parameters will be determined by the strip transect method, adjusting observed numbers by the Emlen technique (Emlen, 1971) for songbirds (and certain non-songbirds) at each of the primary monitoring, control, and habitat enhancement sites during May, July, and September. All transects will begin at a specified small mammal live-trapping station and will be permanently marked.

The strip transect method consists of slowly walking through a strip 800-m (2,624-ft.) long and 122-m (400-ft.) wide; all individual birds seen and heard within this strip are recorded by species on a standard field data form according to their perpendicular distance from the transect at the time of initial observation. Perpendicular distances are recorded according to categories of 0-3 m (0-10 ft.), 3-7.6 m (10-25 ft.), 7.6-15.2 m (25-50 ft.), 15.2-30.5 m (50-100 ft.), and 30.5-61 m (100-200 ft.). A hand-held rangefinder will be used initially to "calibrate" the observer to these distance zones. The exact length of each transect will be determined by tape measurement.

Strip transect censuses are conducted during periods of peak activity, generally within 3.5 hours of sunrise and sunset. To insure reliable estimates of population size, each transect will be surveyed three times during each sampling period.

a) Ground Surveys - During February, a 32-km (20 mi.) census route initiated near the upland sagebrush conversion area (Figure 11-4-1) and located through sagebrush habitat, will be driven for 3 consecutive mornings. (To assess the effectiveness of the bird watering locations, a 24.2-km (15 mi.) census route on 84 Mesa will be driven for 2 consecutive mornings during February.) All sage grouse encountered will be counted, their location plotted on field maps, and birds flushed and sex and age tallied on field data sheets. Criteria for sexing and aging will be based on data presented by Rogers (1964).

3) Raptors - A 48-km (30 mi.) census route will be used to monitor changes in raptor species composition and relative abundance that might result from the habitat disturbance and increased human activity associated with oil shale development. To evaluate the success of raptor mitigative efforts, the route will include each of the habitat enhancement areas. In addition, to determine if raptors are accumlating toxic elements, feathers collected from selected raptor nests will be analyzed for trace elements. Feathers will be collected only after nests have been vacated.

To survey diurnal raptors such as hawks and eagles, the census route will be driven on 3 consecutive mornings during February and July, weather permitting. Raptor surveys are conducted during both winter and summer because of seasonal changes in raptor species composition. All raptors observed will be recorded as to species, location, and sex and age (if possible).

To survey owls, the same road transect will be driven on 3 consecutive nights, also during February and July. These surveys will commence within 2 hours after sunset. The transect will consist of 30 stops, each permanently marked with stakes and flagging tape, located approximately 1.6 km (1.0 mi.) apart. At each stop, the observer will leave the vehicle, walk approximately 15 m (50 ft.) away and record on a field data sheet, by species, the number of owls heard or observed during a 5-minute period. Criteria for determining owl species by vocalization are based on the observer's experience, tape recordings of various species, and information presented by Peterson (1947, 1961), Bent (1961), Craighead and Craighead (1969), Thorpe (1961), and Armstrong (1973).

d. Mule Deer

1) Aerial Surveys - Aerial surveys will be conducted to determine relative changes in mule deer distribution and abundance that might result from the habitat disturbance and increased human activity associated with oil shale development near Tract C-a. These surveys will employ a high-wing Cessna aircraft designed to permit slow flight at low levels above the ground. The plane will be flown along standarized transects (flight paths) within the range of 120-136 km (75-85 mi.) per hour (indicated air speed) at an altitude

of approximately 45.7 m (150 ft.) above the ground. Due to the varied topography, the above-ground altitude may vary slightly within transects; however, the flight paths, speed, and altitude of the aircraft will be duplicated as much as weather conditions permit. Survey flights will be conducted at approimately monthly intervals from late October through early April to assess the mule deer populations during the winter period.

Complete coverage of the area will be accomplished by 13 north-south transects established during the first year baseline investigations. The flight paths parallel each other at approximately 1.6 km (1 mi.) intervals and will be approximately 16.1 to 17.7 km (10 to 11 mi.) long. The census area will extend approximately 8.1 km (5 mi.) each of Tract C-a boundaries to the ridge along Cathedral Bluffs west of Tract C-a.

To permit constant observation of the transect area along the flight paths, portable tape recorders will be used to record information during the survey. All animals seen by the pilot and two observers (positioned on opposite sides of the plane) will be counted and their locations noted. When possible, information on age, sex, activity patterns, and habitat will also be recorded on the cassette tape. General impressions on animal distribution, ground cover characteristics, changing weather conditions, light and spotting conditions, and flight characteristics will be recorded at appropriate times throughout the census flight.

2) Pellet Group Counts - Pellet group counts will be used to monitor the effectiveness of habitat enhancement procedures. Pellet group counts have been used by many researchers to census big game, indicate population trends, and determine distribution patterns of big game animals (Bennet et al., 1940; Julander, 1958; Harris, 1959). The technique involves counting the number of pellet groups deposited during a known time period on an area of known size. This information, coupled with a knowledge of big game defecation rates, can be used to compute the levels of deer use in an area. Several researchers have published defecation rates and other pertinent information on study design, techniques, and field procedures for big game studies (Rogers et al., 1958; Smith, 1964; McKean, 1965; and Neff, 1968).

Ten randomly selected pellet group transects will be established within each of the three habitat enhancement types within 6 months after habitat modification is completed. The distance between plots will be varied to allow all 25 plots on each transect to be located entirely within the modification areas. Plots will be inspected annually during the spring and data compared to pellet plot transects established in relatively undisturbed areas (Zone 3 above) to establish relative mule deer habitat use patterns.

Each transect will consist of 25, 9.3 m^2 (100 $ft.^2$) circular plots spaced at regular intervals along a straight line course. During transect establishment, a 45.7 cm (18 in.) rebar stake will be driven into the ground to mark the center of each plot. The distance between plots on the transect will be measured with a tape measure along a compass course. An aluminum pole, slipped over the rebar stake, will serve as an axis for a rope marked 1.72 m (5.64 ft.) from the center of the stake. When the rope is revolved around the pole, the mark delineates the plot boundaries. A short written description of vegetation and landforms will be recorded for each plot during transect establishment. All old pellets will be cleared from the plots during the establishment phase. Plots will be inspected annually during the spring and pellet groups deposited during the census period will be counted, removed, and recorded on field data sheets.

RBOSP is presently reviewing a plotless method for determing mule deer abundance and distribution. If this technique is applicable to Tract C-a and environs then RBOSP will contemplate substituting this method into the second year baseline program.

4.3 NON-BIOLOGICAL PARAMETERS

A wide range of abiotic factors influence the dynamics of the living components of Piceance Basin ecosystems. For example, the physical-chemical nature of the soil and macro- and micro-climate are two interacting sets of influences which control soil moisture. In turn, the availability of soil moisture in plant rooting zones is the primary environemtal factor which "regulates" the distribution of vegetation in the Tract C-a vicinity. To correctly assess and interpret the effects of oil shale development upon local ecosystems, it will be essential to understand the nature of abiotic-biotic interactions in the study area. Information on soils, climate, air quality, toxic chemicals, and trace elements will be rountinely gathered during the monitoring program and the data applied toward a better understanding of responses observed in biological sampling programs.

A. Soils

1. Introduction - Soil condition and chemical composition not only dictate the distribution and patterning of vegetation in the vicinity of Tract C-a, but they play an important role in the cycling of nutrients and minerals throughout the food chain. Factors such as soil pH, texture, salinity, depth, available moisture ,and temperature will influence the fate of chemical elements in the soil. Since antagonistic and synergistic effects exist between many elements and because availability of these elements to plants and thus to higher trophic levels is affected by these interactions, it is essential to have a broad knowledge of soil elements at each primary monitoring and control site. Moreover, it is important to have a good baseline on concentration of toxic trace elements present in the soils before evaluating the significance of additional accumulations of the same elements from plant operations.

The chemical and physical nature of the different soil types in the vicinity of Tract C-a are presently being determined. This information should be available for use in the pre-operational monitoring program. To correctly interpret changes in vegetation during operational monitoring, physical soil factors such as pH, salinity, moisture, and temperature will be regularly determined in conjunction with the performance of the rest of the monitoring program. Particular emphasis will be placed on the regular measurement of soil moisture as a most critical "controlling" environmental factor. A method for monitoring accumulation of potentially toxic elements in the soil is outlined in Section 4.3.D.

2. Methods and Materials - Soil samples will be collected every 5 years during late spring and analyzed by a commercial laboratory.

B. Meteorology

1. Introduction - Micro- and macro-climatic conditions play an important role in determing vegetation distribution cover and condition in the vicinity of Tract C-a. Meteorological stations will be located as identified in Section 11, Chapter 3.

2. Methods - See Section 11, Chapter 3.

C. Air Quality

1. Introduction - Air quality monitoring will be an important tool for predicting what elements, both gaseous and particulate, may prove hazardous to the environment. Air quality stations will be located as identified in Section 11, Chapter 2.

D. Chemical and Trace Element Analysis

1. Introduction - Chemical and trace element analyses will be conducted on soils if the soil analyses indicate the availability of toxic substance uptake by plants. This may provide RBOSP with an "early warning" of potential hazard to terrestrial ecosystems from retort emissions. A firm literature base which documents the effects of bio-accumulation of various toxic elements is continously developing (Price, et al., 1974; Giles, et al., 1973; Schroeder, 1971; Stern, 1968; Peakall and Lovett, 1972; Huckabee, et al., 1973; Dewey, 1973; Eagers, 1969; and Underwood, 1962). To properly interpret the relation between the increased concentration of an element in a particular ecosystem component (i.e., soils) and increased stress on the ecosystem, it is necessary to have a broad understanding of both the element and the component sampled. With regard to the former, factors such as source of the element, its chemical form, its synergistic or antagonistic effect with other elements, and availability of the element for uptake are important. In the soil component, the retention

and thus availability will determine the toxicity potential of that element to plants. If the soil data analyses indicate further study, then selected species of plants will be considered for analysis. If this analysis indicates probable contamination to the animal component, selective species will be analyzed for those toxic materials as identified in the previous group. Should a series of analyses indicate that a given species of plant or animal is concentrating or biologically magnifying on a compound, then this individual would receive constant analysis. Comparison of pre-operational and operational trace element and chemical levels and comparison of levels at both fumigated and control sites will permit determination of the effects of possible increases in trace element and toxic chemical levels on the terrestrial ecosystem.

Specific studies directed at describing the toxic chemicals and trace elements found in oil shale are presently underway, with data analysis proceeding as scheduled. Presently, the trace elements and toxic chemicals tentatively selected for monitoring include selenium, zinc, mercury, sulfur, fluoride, molybdenum, arsenic, lead, and chloride.

A description of each trace element and its possible effect on plants and animals is provided below. As more data becomes available, certain elements may be dropped and/or others added.

a. Selenium - Levels of selenium in soils vary a great deal, but most soils contain 0.1 to 2.0 ppm (Chapman, 1966). Elemental selenium is generally non-toxic because it is poorly absorbed by the biota. Certain plants such as Astragalus sp. are known concentrators of selenium and may contain 50 to 15,000 ppm in areas where selenium levels in the soil are high. These plants pose a hazard to animal consumers, since selenium at high levels is toxic to most species. At low levels, selenium is an essential element to higher animals and may reduce the deleterious effects of other toxic elements like cadmium and magnesium (Hoekstra, et al., 1974). Chronic selenium poisoning has caused blind staggers in cattle, and in many animals can lead to dullness, lack of vitality, loss of hair, anemia, liver pathology, (as evidenced by atrophy, cirrhosis, and hemorrhage), necrosis, and restricted food intake.

b. Zinc - Total zinc levels in soil normally vary from 10 to 300 ppm and are usually concentrated in surface rather than subsurface layers. Zinc is essential to both plants and animals and normally does not occur in toxic amounts. In a variety of plants, normal levels range from 25-150 ppm and amounts greater thatn 400 ppm indicate toxic levels of zinc (Ratsch, 1974). Zinc is incorporated into the skeleton very slowly and remains firmly bound for a long time. Toxicity symptoms are characterized by depressed growth and anemia due to reduced food consumption.

c. Fluoride - Normal fluoride levels in soil show a very broad range, with sandy soils generally having the lowest and clay-like soils the highest levels. The effects of the fluoride present in soils are dependent on whether soluble or insoluble forms are present, since this will determine its availability for uptake. Plants have a low capacity fo absorb fluoride from the soil, but absorption from the air to plant cytoplasm takes place readily when soluble forms are present. In soil, fluoride may inhibit seed germination and soluble fluorides up to 100 ppm greatly diminish seed germination; 400 ppm of fluoride inhibit germination in corn (Eagers, 1969). Many plants will accumulate fluoride without signs of toxicity. For example, certain grasses may accumulate several hundred parts per million without damage. In Douglas-fir, normal levels are 0.1 to 0.2% (Ratsch, 1974). Susceptible species such as ponderosa pine may be affected by hydrogen fluoride levels far below 1 ppm, young leaves and needles being the most susceptible (Naegele, 1973). Fluorosis in animals may be caused by toxic levels in water, soil, air, or food. Toxicity is evidenced by damage to the kidney and liver, nasal passages, bone marrow, and skin. Symptoms include modification of non-permanent teeth, stiffness, lameness, and weight loss due to reduced food consumption. Young animals are the most susceptible.

d. Mercury - The mercury of soils in the United States is highly variable but averages about 100 ppb. Mercury salts show low solubility and are absorbed by organic and inorganic materials in the surface soil. Mercury is, however, volatilized and, as erosion is increased, the volatilization may also be increased. The toxicity of mercury in terrestrial plants depends more on the chemical form of the element than on concentrations in the plant.

Toxicities to plants are unknown and the normal concentration range in plants is 10 to 200 ppb, with an average of 15 ppb. In animals, toxicities also depend on the form of mercury. Methyl mercuries are retained for long periods, but aryl and inorganic forms are retained only a tenth as long as toxic forms. Chronic poisoning by elemental mercury is characterizer by renal damage, depression, instability, and tremors. In a study on coyotes and rodents in Wyoming, 0.6 ppm of mercury was determined to be a realistic maximum natural concentration (Huckabee, et al., 1973).

e. Molybdenum - Soil concentrations of molybdenum usually average 2.5 ppm. The availability of molybdenum to plants is, however, determined by pH and soil levels of sulfate, phosphate and manganese. In acid soils, for example, molybdenum is not readily absorbed. Molybdenum levels greater than 5 ppm in soils are potentially dangerous when taken up by plants. Legumes accumulate maximum amounts of molybdenum, especially during periods of rainfall. Molybdenum has also been found to be an essential element in animals, so toxicity depends on the level of intake and the nature of the compounds. Molybdenum is excreted in urine and under toxic conditions results in diarrhea and general deterioration of the animal's condition.

f. Sulfur - Sulfur levels in soil are influenced by leaching. Accumulation of sulfur from the substrata seldom causes toxicity as do airborne sulfur compounds. Refer to Section 10-5 for a complete discussion of the effects of airborne sulfur (SO_2) on plants and animals.

g. Chloride - Because soil chloride is readily leachable, it does not usually accumulate in soils except during dry periods. However, substantial amounts are taken up by plants so chloride is not necessarily lost from the system by soil leaching. Chloride concentrations in plants increase as the tissue ages, so chloride levels in the fall can be higher than in the spring. Although chloride is an essential element for both plants and animals (generally obtained by animals by eating salt) excessive levels of chloride which could result from cooling tower salt drift may cause toxicity to plants (Section 10-5) and animals.

h. Lead - Lead concentrations in soils may show a broad range from 2 to 200 ppm, but the concentration in soil by itself is not important since most of the lead in soil is insoluble and thus unavailable for plant uptake. Concentrations of soluble lead usually range from 0.05 to 5 ppm. Lead is relatively non-toxic to plants but can be highly toxic to animals, particularly when airborne lead is taken into the lungs. At toxic levels, damage is done to the liver, kidney, brain, central nervous system, and reproductive system. Excessive levels of lead in mice and rats can shorten the life span (Schroeder, 1971).

i. Arsenic - The majority of soils contain less than 10 ppm arsenic. Arsenic is usually leached from most soils but may be accumulated by plants, usually in or on the roots. Arsenic compounds may be toxic to plants and animals at high concentrations.

2. Methods and Materials

a. Collection of Data - Concentrations of several potentially toxic elements in soils and selected organisms at each level in the trophic pyramid will be monitored. Criteria for selection of plant and animal species include their importance in the ecosystem, their utility as indicators or accumulators of certain elements, and their availability for sampling. Animal tissues or parts of tissues documented to be sites of accumulation will be used in the analysis. Since pesticides or herbicides may also accumulate in certain organisms and can potentially inflict damage on non-target species, organisms will also be examined for these chemicals if spraying is suspected to have occurred nearby.

1) Soils - Soil samples will be collected every 5 years from primary and control sites and analyzed by a commercial laboratory.

2) Vegetation - If the soils data indicate a concern over any of the previously identified trace elements, then the vegetation will be of potential toxicants in the species of plants that occur near Tract C-a. Two species of representative grasses (ricegrass and wheatgrass), two shrubs

(rabbitbrush and sagebrush), and two trees (pinyon and juniper) have been chosen, and concentrations of any elements discussed in the introduction will be determined. In addition, certain species have been chosen because of their documented ability to concentrate an element and will be analyzed only for this element. These include selenium indicator species such as Astragalus and facultative selenium accumulators such as Aster, Atriplex, Gutierrezia, and Penstemon (Kingsbury, 1964). Astragalus is also a sensitive species to sulfur dioxide as are Oryzopsis hymenoides, Hedysarum boreale and Gutierrezia. Molybdenum concentrations will be analyzed, especially in legumes such as Astragalus sp., Trifolium gymnocarpon, Hedsarum boreale, Oxytropis lambertii and Lupinis caudatis. Vegetation sampling will coincide with soil sampling unless data indicates a more frequent sampling schedule. Plants will be collected at each primary monitoring and control site, but will be taken sufficiently far from permanent vegetation transects at these sites to avoid biasing data obtained from existent vegetation. Similar species at all sites will be chosen for analysis, and atomic absorption pectrophotometry will be conducted by a commercial laboratory.

3) Invertebrates - If invertebrates need analysis, the frequency of collection will be determined by the data previously collected and the chemical involved. Nevertheless, collection will occur on both the primary and control sites. Care will be taken to sample at approximately the same time each year, since seasonal variations do occur in invertebrate species composition (Nation and Robinson, 1971). Leaf-cutter bees will be collected with nesting boxes and Malaise traps and will be preserved with ethyl alcohol (Middleton, et al., 1973) or by freezing (Christian and Feldman, 1970). Composites will be made of at least 1 gm of specimens of the same species. They will be submitted to a commercial laboratory for analysis by atomic absorption as suggested by Levy and Cromroy (1973) and Middleton, et al. (1973). Fluoride, lead, sulfur, arsenic, zinc, and mercury concentrations will be determined. Similar analyses will be carried out on harvester ants at each site. These will be collected by hand-picking.

4) Vertebrates - Composited samples of selected small mammal tissues from five adult males of both the deer mouse (Peromyscus maniculatus)

and the least chipmunk (Eutamias minimus) will be analyzed by atomic absorption, wet chemistry, or specific ion probes where applicable. Small mammals will be collected by a line of 40 live traps established sufficiently far from live-trapping grids at each site to avoid collection of marked animals (Section 4.2.C). Both the deer mouse and the least chipmunk show a mixed diet of seed, succulent, and insect material and thus may accumulate toxic elements from several sources. The analysis will include liver samples for selenium and sulfur; bone for zinc, fluoride, and molybdenum; hari for lead, arsenic, and mercury; blood plasma for sulfur; and feces for zinc. When one tissue looks suspect in its concentration of a certain element, another tissue sample may be chosen to confirm it. In addition, fur from rabbits collected in strategically placed live traps will be examined for mercury, arsenic, and lead.

4.4 MONITORING ANALYSIS

The purposes of this section are to tie together all monitoring methods, to demonstrate overall monitoring design and to present examples of how monitoring results will be interacted to demonstrate the effects of oil shale development on the Tract C-a and surrounding ecosystems. The interrelations of all results are varied and many, thus, will not be presented here. The examples given, however, should provide an indication of the direction of this monitoring program. As this program is going to remain flexible throughout its lifetime, the actual data analysis result interrelations will be subject to change as the program evolves.

A. Study Site Design

Eight primary monitoring sites will be placed in areas where processing emissions and area disturbance impacts are expected to occur. Each of the sites selected for monitoring of process emissions will be placed in areas of different emission levels, based on the air quality model (Section 9, Chapter 5). Therefore, each of these sites should be subjected to different pollution levels resulting in the establishment of "pollution gradient" monitoring sites. Monitoring sites placed next to areas of land disturbance will be used to monitor the effects of species dispersal, dust, noise, etc. on these areas.

Monitoring sites will also be established within habitat enhancement areas to demonstrate the effectiveness of these areas.

Control sites will be placed in areas where oil shale development impacts are not expected to occur. These sites will be used as comparison with primary monitoring sites to demonstrate possible oil shale development produced environment changes. In addition, these sites will be used as the basis to judge the effectiveness of the enhancement sites.

B. Statistical Design

The ultimate "brunt of burden" for proof of environmental changes will be placed on the control sites. Therefore, their placement and data analysis will be closely scrutinized. Data collected at these sites will be carefully analyzed both within and between sites. The ultimate goal of the analysis is not only to act as a basis to monitor environmental changes, but also to establish the normal background variation occurring in the natural environment, outside of which the environmental assessment can be made.

As stated previously, the overall monitoring statistical design will be divided into two phases. During the first phase (pre-operational), which will occur before the start of operations, the monitoring system will be "fine tuned". To do this, parameters collected at all monitoring sites will be compared both within a site, and between sites, to see whether certain parameters statistically differ and to demonstrate the degree of that difference. These differences (or lack of such) will be used to establish the baseline conditions to which the assessment environmental changes can be made. The second phase (operational) of the monitoring statistical design will occur during oil shale operations. During this phase, parameters will be statistically compared within each monitoring site, between monitoring sites (both within primary sites, primary sites to control sites and control to control sites) and with the "baseline" established results. In addition, to these comparisons, statistical tests will also be applied to a comparison of year to year data. Again, the tests run will determine whether parameters statistically differ by site, by control and by year.

For example, soil trace element studies will be utilized to determine whether stack emissions are causing a build up of certain trace elements in the soil. The baseline studies will establish the statistical "point of origin" at which further comparisons of trace element studies can be made.

As soil samples are collected during the operation phase, statistical tests will be run of these samples comparing them to the baseline samplings. The hypothesis to be tested will be that no difference exists between baseline conditions and operation conditions (i.e., plant operations are not causing a buildup of trace elements in the soil). If this hypothesis (the null hypothesis) is true, then no further investigations of trace elements are required. If this hypothesis proved to be false (i.e. processing stack emissions are possibly causing in increment in the levels of trace elements in the soils around the processing plant), then further analysis may be required.

Statistical treatments will then be given to a comparison of trace elements between the monitoring site and control site. Again, the mull hypothesis will be tested.

The next step in the data analysis process will be to compare soil trace elements between each of the monitoring sites. As each monitoring site was placed in area subjected to different levels of air pollutants, it is expected that trace elements may buildup according to each respective emission level. This is where the "pollution gradient" concept takes effect. Correlations will be made between all monitoring sites to determine whether emissions levels do differ at each site (and the degree of that difference) and possibly demonstrate the accuracy of the air quality model.

Trace element studies will be conducted to detect the presence and concentrations of elements in plants, the major entryway of trace elements into the ecosystem. If trace element buildup is found, both in the soil and plant tissue, then analysis of insect or small mammal tissues will be enacted to determine trace element presence there. If shown then, it will warrent statistical analysis will be applied to a variety of parameters such as plant productivity or biomass, or animal population dynamics in an attempt to establish a correlation between trace elements and ecosystem function. The end results of the trace element studies and analysis would be the demonstration of their effects on the ecosystem, and the formulation of effect mitigative procedures if adverse impacts occur.

C. Parameter Interaction

The above example of trace elements analysis is a simplification of the many pathways that can be taken to monitor and assess impacts. The example is not limited to trace element analysis, but is an indication of the way that all applicable monitoring parameters can be analyzed both among and between individual parameters. As alluded to in the example, an holistic approach will be utilized in ultimately determining the effects of oil shale development. Through this type of approach, multivariate analysis will be applied to a variety of applicable parameters in order to establish correlations and cause and effect relationships.

Thus, through the analysis process, plant biomass can be compared to animal population levels, plant vigor can be related to insect (kinds and numbers) presence, bird populations related to insect levels, dust and noise levels (presence or absence) can be related to animal species presence or absence and so on.

The overall effectiveness of habitat enhancement procedures will be determined through the interaction of parameters. Thus, a corrleation between increased available plant biomass and an increment in animal numbers is one way habitat enhancement can be evaluated.

The final step of monitoring analysis will be to correlate data assimilated during all phases of the baseline and monitoring programs to describe the effect and extent of each impact on the whole system. The holistic approach will allow a complete assessment of environmental changes brought about by oil shale development, thereby aiding in the formulation of possible corrective (mitigative) procedures, both of which are the main goals of this monitoring program.

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CHAPTER 5
AQUATIC ECOLOGY

5.1 AQUATIC COMMUNITIES

The aquatic communities or assemblages included in the RBOSP aquatic baseline studies included the benthos, periphyton, phytoplankton, zooplankton, aquatic macrophytes and fish. During the initial year of aquatic baseline studies, trends in the baseline data suggest that certain of these communities may provide a more definitive assessment of the natural and man-related trends in the aquatic ecosystems during the monitoring phase of the Rio Blanco Oil Shale Project. Use of these biological parameters in monitoring will also provide insight into the effectiveness of the RBOSP water quality control plan. In addition, certain physical and chemical parameters which, from the initial year of baseline data, appear to influence the biotic community composition and abundance will be an integral part of an aquatic monitoring program.

Based upon the initial year of baseline data, it appears that the major source of autochthonous primary production in aquatic habitats of the area is the periphyton, while the phytoplankton generally constitute a secondary source of such production. The secondary consumer level in aquatic habitats on or near Tract C-a is generally occupied by benthic invertebrates and, to a lesser extent, by planktonic invertebrates (zooplankton). In addition, fish (which generally confine their range to the White River) act as either secondary or tertiary consumers.

Because of their dominant role in the aquatic ecosystems of Tract C-a and vicinity, and because of their limited mobility and thus their susceptibility to physical and chemical changes, the benthos and periphyton communities will be included in future monitoring programs. The abundance, species composition and diversity of these organisms will be evaluated to assess trends due to natural and man-induced variations. In addition, studies of fish species composition, abundance, age and growth, and condition factors will be included in future monitoring. The comparison of condition factors between the baseline period and some future period is particularly useful in assessing environmental perturbations.

The physical and chemical parameters to be utilized in monitoring of aquatic ecosystems will likely include water temperature, dissolved oxygen, pH, specific conductance, velocity of flow, total alkalinity, depth, width, turbidity, suspended solids, dissolved solids, total solids, calcium, magnesium, sodium, potassium, silica, chloride, sulfate, dissolved organic carbon, total organic carbon and selected inorganic nutrients. The importance of temperature, turbidity, alkalinity, suspended and dissolved solids, dissolved oxygen and current velocity have been noted during the initial year of baseline studies. Evaluation of data from the second year of baseline studies will provide further rationale for addition or deletion of physical and chemical parameters as well as biological parameters.

5.2 OBJECTIVES AND METHODS

A. Physical Measurements

1. Objectives - The objectives of this aspect of the Aquatic Monitoring Studies will be to monitor selected physical characteristics of the streams at each sampling site and to relate these characteristics to baseline chemical and biological conditions. The physical measurement program will also include those chemical parameters which are measured in conjunction with field sampling operations.

2. Methods - The following methods will be used to determine selected physical characteristics at each sampling site. These determinations will be made concurrently with the collection of chemical and biological samples. Stream velocity will be measured with a Gurley flowmeter. The stream substrate will be visually classified at each station at the same time as benthic samples are collected. Color and odor will be determined for each sample by methods described by the American Public Health Association (APHA, 1971). The turbidity of each sample will be determined with a Hach Photometric Turbidimeter. Field measurements of dissolved oxygen will be taken with a portable dissolved oxygen meter or with the Alsterberg (Azide) modification of the Winkler Method (APHA, 1971).

Other parameters (and methods of measurement) which will be determined in the field include pH (portable meter), specific conductance (portable meter), water temperature (thermister or equivalent), depth, width, and alkalinity (colorimetric; APHA, 1971).

B. Chemical Measurements

1. Objectives - The objectives of this aspect of the Aquatic Monitoring Studies will be to monitor certain chemical characteristics which have been determined to be of particular biological significance to the streams and to

relate these chemical data to physical and biological data collected during baseline studies.

2. Methods - Duplicate samples will be collected at each sampling station. Chemical determinations will likely include: ammonia nitrogen, dissolved calcium, dissolved chloride, total hardness, dissolved magnesium, Kjeldahl nitrogen, dissolved nitrate, dissolved nitrite, dissolved orthophosphate, total phosphate, dissolved potassium, dissolved silica, dissolved sodium, dissolved sulfate, dissolved organic carbon, total organic carbon, suspended solids, and total dissolved solids.

The analytical methods, limits of detection and methods of sample preservation for the aforementioned analyses will be the same as those utilized during baseline studies.

C. Sediment Studies

1. Objectives - The objectives of this aspect of the Aquatic Monitoring Studies will be to monitor certain characteristics of stream sediments to provide a measure of current conditions for comparison with conditions which prevailed before tract development was initiated.

2. Methods - Duplicate samples will be collected at each sampling station. Chemical determinations will include the following parameters: aluminum, arsenic, lead, mercury, Kjeldahl nitrogen, total phosphate, volatile solids, and zinc.

Analytical methods will be the same as those utilized during aquatic baseline studies.

D. Periphyton

1. Objectives - Periphyton studies will be conducted to determine the effect of development on species composition, standing crops and diversities of periphyton communities.

2. Methods - Six samples will be collected at each station from natural substrates. Three of these will be used to estimate abundance and three will be used to determine biomass. Periphyton samples will be collected from natural substrates.

E. Benthos

1. Objectives - The objectives of the benthos (macroinvertebrates) studies during the monitoring program will be to describe the benthic community at each sampling station. This will include taxonomic composition, abundance of these described taxa, and species diversity indices.

2. Methods - At each station, triplicate samples will be collected using a modified Surber sampler, and Ekman grab, or a D-frame sampler. In most cases the modified Surber sampler will be used. It has been shown to be effective in rubble and gravel substrates, and gives quantitative results. The Ekman grab will be used at pool Station 14. The D-frame sampler will be utilized to collect benthos in the White River on those occasions when the water depth, type of substrate and current velocities require its use.

After collection, benthos samples will be washed in buckets with bottoms fitted with a U. S. Standard No. 30 sieve, and preserved with neutralized 10% formalin. Laboratory methods will be those utilized during aquatic baseline studies.

F. Fish

1. Objectives - The objectives of fish studies will be to monitor trends in community composition and determine certain aspects of growth, spawning and conditon as development proceeds.

2. Methods - Fish collections will be limited to the White River. They will be made by electrofishing methods similar to those used in baseline studies. Stream sections of appropriate length will be sampled. The

probes will be moved upstream where possible, and sometimes downstream. Stunned fish will be picked up with dip nets. Each station will be sampled twice during each sample period. Back channels will be blocked off during sampling with seines during low flow periods.

Captured fish will be held in holding nets or buckets of water until one or more stations has been sampled. The larger fish will then be weighed to the nearest gram and measured (total length) to the nearest millimeter. Stomachs will be excised from some of the larger fish for laboratory analyses, while smaller fish will be preserved whole. Scales will be taken from appropriate species. Laboratory methods will be similar to those used during baseline studies.

Length-frequency analyses will be done on flannelmouth suckers, mottled sculpin, and speckled dace by the same method used during baseline studies.

Condition factors (K) will be computed from the formula given below:

$$K = \frac{W\,10^5}{L^3}$$

where W = weight in grams
L = total length in millimeters
and 10^5 = a factor to bring K near unity

Statistical methods to be used during monitoring will include the use of analysis of variance in comparison of baseline and monitoring data. In addition, community diversity will be evaluated through use of Shannon Evenness Index and Index of Richness.

5.3 SAMPLING LOCATION

Based upon the data obtained during the initial year of aquatic baseline studies and upon the assessment of potential effects of the Rio Blanco Oil Shale Project on existing aquatic habitats, the following sampling sites have been selected for monitoring short-term and long-term trends:

- Station 5 (pond-seepage habitat) in Stake Springs Draw
- Station 7 (spring-brook habitat) in Corral Gulch
- Station 8 (spring-brook habitat) in Box Elder Gulch
- Station 9 (spring-brook habitat) in Corral Gulch
- Station 13 (spring-brook habitat) in Corral Gulch
- Station 14 (pond habitat) in Corral Gulch
- Station 15 (spring-brook habitat) in Corral Gulch near its confluence with Stake Springs Draw
- Station 19 (pond habitat) in Yellow Creek
- Station 20 (spring-brook habitat) in Yellow Creek
- Station 23 (back-channel area) in the White River
- Station 25 (riffle area) in the White River
- Stations 27, 28, 29 (back-channel area) near the confluence of Yellow Creek with the White River
- Station 33 (back-channel area) in the White River
- Station 34 (riffle area) in the White River

These stations represent all major aquatic habitat types and aquatic biota encountered in the area and include areas most susceptable to disturbance as well as downstream areas which would serve in monitoring the effectiveness of the Water Control plan. During the monitoring phase of the study deletions and/or additions to selected sampling locations can be expected. This list of sites also includes three USGS gaging stations.

5.4 SAMPLING FREQUENCY

The frequency of aquatic sampling during the monitoring program will be designed to determine natural and human-related variations in the aquatic communities being monitored. An evaluation of natural variations observed during the baseline studies will determine the sampling frequency required to follow the natural variability in aquatic communities.

An evaluation of the initial year of baseline data suggests that the sampling frequency required to record trends in aquatic ecosystems on and near Tract C-a is three to four times during the period from April to November. After collection and evaluation of additional baseline data, the sampling frequency to be utilized during the monitoring phase can be more precisely defined.

LITERATURE

American Public Health Association (APHA). 1971. Standard methods for the examination of water and wastewater. Thirteenth edition. American Public Health Association, Washington, D. C. 874 pp.

CHAPTER 6
HYDROLOGY

The following proposed monitoring programs are based on the data available after one year of baseline data gathering. As additional data are collected, some of these programs may be subject to change. It should be noted that all monitoring programs must be approved by the AOSS. The limits of detection for the various constituents in the water will be at or below those limits established safe for drinking water.

6.1 SURFACE WATER MONITORING

As described in Section 3, Chapter 4, six precipitation gages and eleven stream gaging stations have been and will be used to collect data during the two-year baseline period. Figure 11-6-1 shows the location of these gages. It is proposed that these stations remain in their present location during the Phase I and II mining operations. The precipitation data collection would remain unchanged through the mining period, although additional gages may be added.

The springs and seeps, shown on Figure 3-4-4 and those found during the second year of baseline data collection, would be visually monitored monthly. The purpose of this monitoring would be to establish if any reduction in flow was occurring due to the dewatering of the Tract C-a mine. Section 10, Chapter 3, discusses the mitigative procedures to be taken.

The surface water gaging stations would continue to monitor conductivity, temperature and flow on a continuous basis and would continue automatically sampling sediment discharge. The number of chemical constituents analyzed monthly during the baseline period would be reduced during the mining period based on results of two years of baseline data. It is proposed to analyze water samples for the complete suite of baseline constituents on a semi-annual

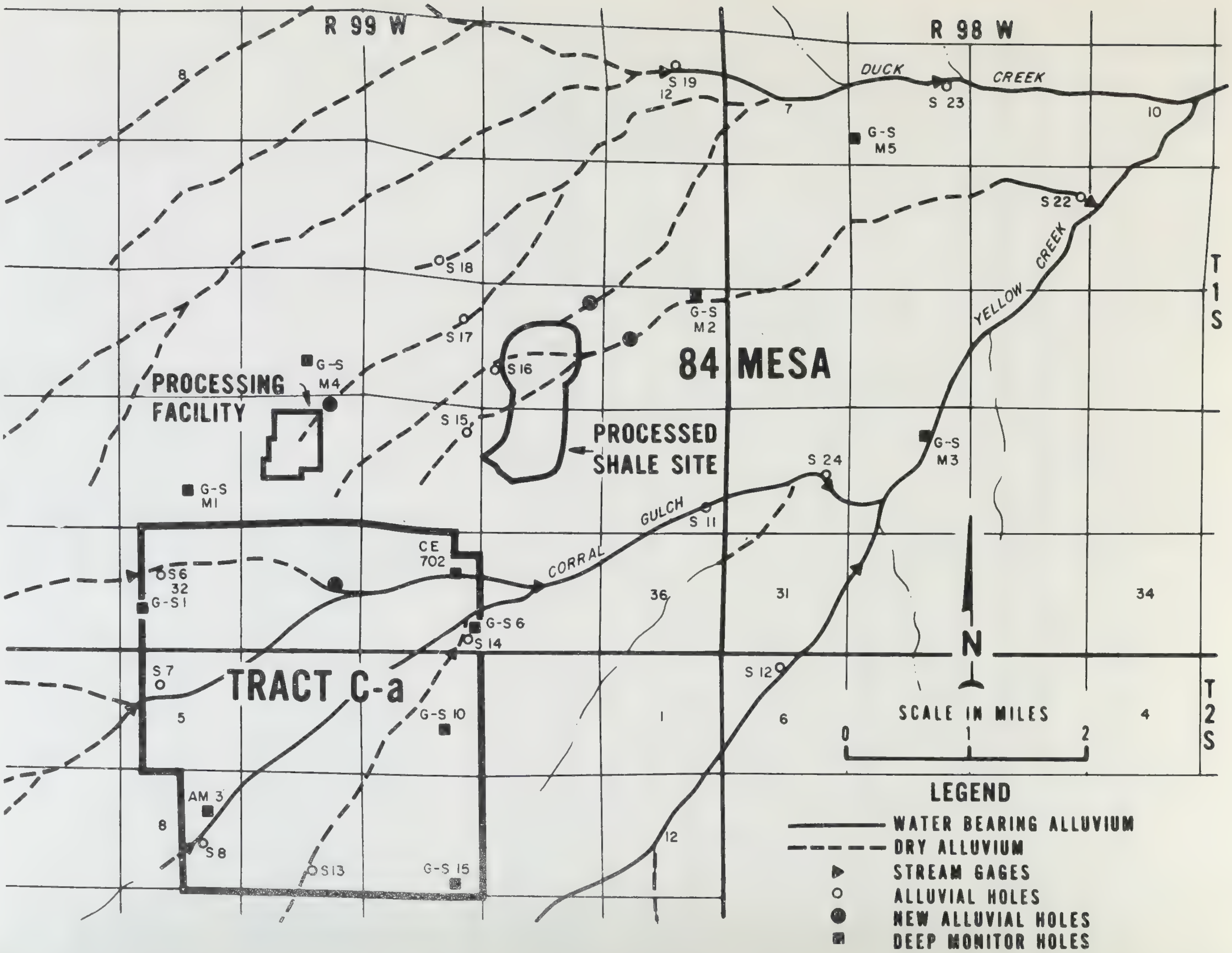

Figure 11-6-1

LOCATIONS OF STREAM GAGING STATIONS AND WATER MONITORING HOLES basis, during June and January of each year if continuous flow occurs, or at least twice a year during flow events. Where feasible we intend to sample upgradient and downgradient of disturbed areas during runoff events.

During the Phase I and II mining operations the ground waters from the upper and lower aquifers will be the primary water supply for the mining and associated operations. During the baseline period the following chemical constituents have been found in higher concentrations in the upper and lower aquifer than in the surface waters: ammonia, bicarbonate, fluoride, lead, sodium, zinc and pH. Although boron and coliform values were not higher in the deep oil shale aquifers, they would also be analyzed monthly at the stream gaging stations. Should any of the values be found in the streams at greater concentrations than the maximum natural values found during the baseline period, a complete analysis would be made. It should be noted that the proposed alluvial holes directly downstream of the possible pollution source should detect, in most cases, the discharge of pollutants before they enter a stream. These monitor holes would be reestablished as the open pit mine and disposal site expand. If it were determined that possible pollution had occurred, the possible source would be investigated. If a source is located, preventative action would be taken to stop the source of pollution. If during the mining period, a spill should occur action would be taken to determine the extent of the pollution and feasible corrective measured would be taken.

6.2 GROUND WATER MONITORING

During the baseline period a total of 15 shallow alluvial monitor holes have been drilled and are being monitored as described in Section 3, Chapter 4, and shown on Figure 11-6-1. The water levels would continue to be monitored on a monthly basis. The chemical constituents would be reduced to the same constituents analyzed for on a monthly basis from water samples at the surface gaging stations. Also as per the surface gaging station a complete analysis for the baseline constituents would be completed twice a year.

It is proposed that four additional alluvial monitor holes be added. The final location of these holes will be such as to detect hydrologic and/or chemical changes in the alluvium as quickly as possible. These holes would be located as follows during Phase I operation:

- Section 33, T. 1 S., R. 99 W., down gradient of the proposed sewage treatment pond on tract.
- Section 28, T. 1 S., R. 99 W., down gradient of the proposed processing area north of the tract.
- Sections 23 and 24, T. 1 S., R. 99 W., 2 holes in different drainages below the proposed processed shale site.

These holes, as shown on Figure 11-6-1, would have automatic water level recorders installed. With the possible exception of the new hole on Tract C-a, the alluvium is not water bearing at these sites, as determined from our baseline studies. Therefore, if the alluvium is dry, any water found in these proposed holes after the beginning of the mine operation would be assumed to come from a possible pollution source. The possible pollution mitigation procedure outlined for the surface water gaging stations would be followed.

The deep oil shale aquifers described in Section 3, Chapter 4, have been monitored in 31 holes during the baseline period. It is proposed that this number be reduced to 11 holes as shown on Figure 11-6-1. Monitor hole AM 2A was dropped and G-S M5 was added to the earlier proposed list of permanent monitor holes. It is anticipated that the present monitor holes will be converted to permanent monitor holes or those no longer needed will be plugged and abandoned after the second year of baseline data has been collected. These holes would be monitored to determine the water levels at regular intervals. Most of the holes would have recording devices installed.

As the ground water gradient in the area of the mine would be toward the pit, because of the dewatering operation, water quality analysis should not be required in these deep aquifers, with the possible exception of G-S M-5. This hole is completed in a possible perched aquifer and as such would not be affected by dewatering. It is proposed that this hole have the baseline chemical analysis run twice a year.

As previously stated, the ground-water gradient during dewatering, lasting the life of the mine, is toward the mine. Therefore, the dewatering and/or mine discharge will be analyzed frequently to determine the chemical constituents and their amounts present in the water. Continuous conductivity measurement will be made if the rate of change in this parameter warrants.

As determined by the ground-water model, discussed in Section 4, Chapter 3, the ground-water levels of the upper and lower deep oil shale aquifers in other areas of the basin may be reduced during dewatering. The possible impacts of this ground-water level reduction is discussed in Section 10, Chapter 3. It is planned that the USGS holes, shown on Figure 11-6-2, will be monitored to determine the dewatering effects on water levels in other parts of the basin. This monitoring would consist of monthly water level measurements by RBOSP as well as attaining supplemental water level data from the USGS. Also shown are existing USGS surface gaging stations. Data from these stations would be of a secondary importance, due to the vagaries of surface water flow.

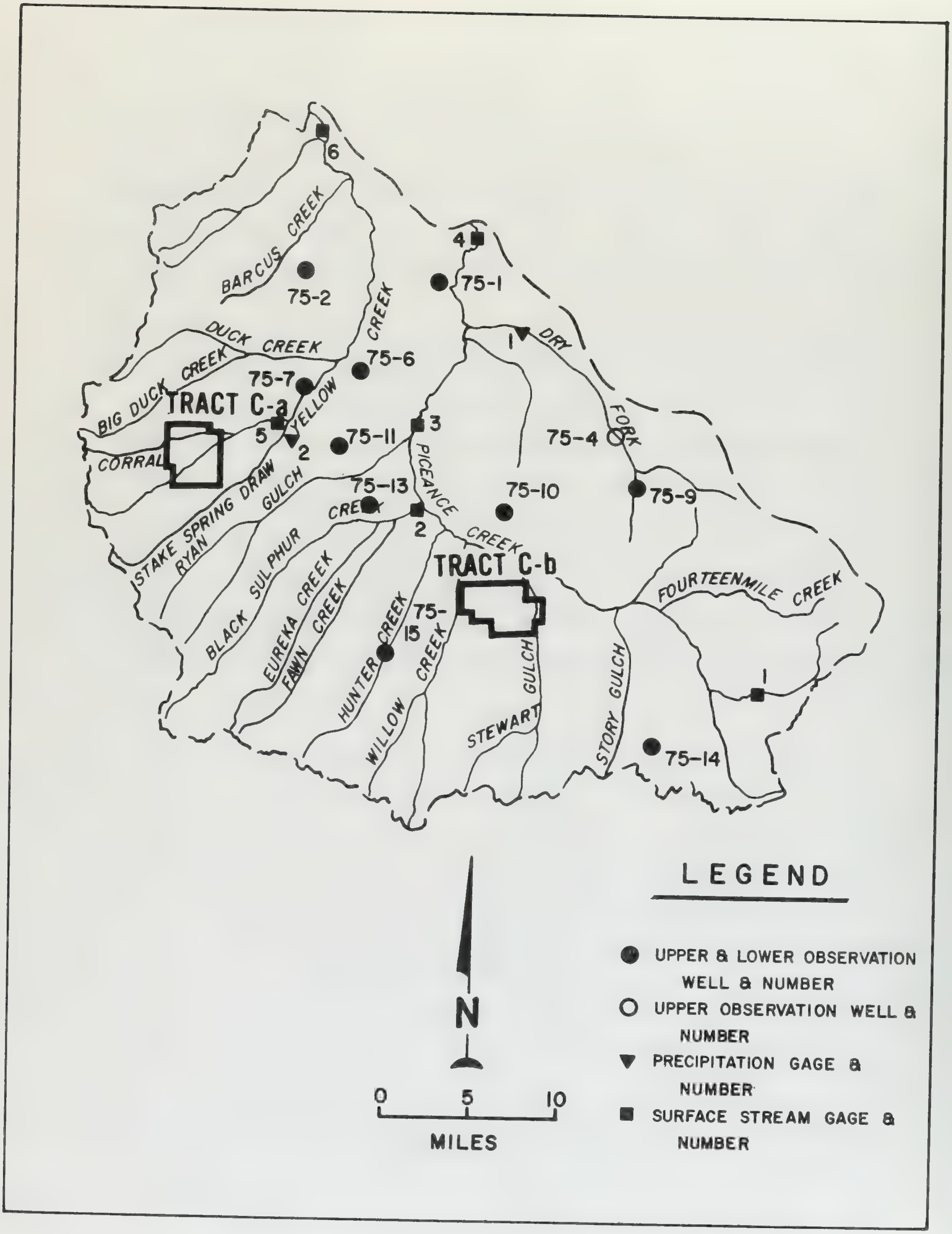

Figure 11-6-2

RBOSP WATER AUGMENTATION PLAN MONITORING PROGRAM

CHAPTER 7
REVEGETATION

7.1 CRITERIA FOR SUCCESS

Several problems are associated with evaluating success of revegetation efforts. Since elevation and topography of processed shale and overburden disposal sites will cause micro- environmental regimes to differ from current conditions, a deviation in the kind and number of flora and fauna from present conditions is expected. Changes in species composition, percent cover, and productivity will occur in revegetated areas as a result of succession. Therefore, ultimate success can only be determined when a self-sustaining community is established. The final species composition is impossible to predict and will depend upon invading natural seed sources in the area, the viability of introduced species, climatic conditions during succession, and grazing by feral and domestic animals. Although there are inherent problems in determining success of revegetation efforts, RBOSP, in compliance with the spirit of lease stipulations, will adopt the objective of reclaiming disturbed areas in such a way that the net result of the subsequent reclamation will be that flora and fauna of the area will be equivalent to or better than that which existed prior to disturbance. The area which will be disturbed by mining includes Tract C-a and the potential offsite disposal area. The vegetation of this area consists primarily of pinyon-juniper, sagebrush scrub, and mixed mountain brush (occupying approximately 40%, 50%, and 5% of the area, respectively). The subsequent revegetation will include varied seed mixtures and transplants which will provide diversified communities in conjunction with the varied slopes, aspects, and terraces that are revegetated on the disposal piles. These communities will provide the diversity necessary to support the fauna currently occurring in the area. Productivity of desirable plant species which will support this fauna is the primary criterion for determining the success of revegetation efforts. Natural productivity of the vegetation types within the area ranges from 105 kg/ha to 271 kg/ha (RBOSP Annual Report, 1976). Productivity of the revegetated areas will vary in relation to the vegetation types established. In addition, the percent cover of the vegetation types varies naturally and an average cover of 35 to 40% is expected for successful revegetation which assumes overlap between the vegetation strata. These values of productivity and percent cover may be exceeded in the revegetation areas due to the configuration of the artificial soil profile which should provide good soil moisture conditions. Other characteristics (e.g., equitable distribution of vegetation and soil stability) will further indicate the degree to which the objectives of revegetation have been accomplished. Reproductive success will ultimately determine the self-sustaining capacity of the system and its long-term stability.

7.2 MONITORING PROGRAM

A. Objectives - The objective of the revegetation monitoring program is to insure that successful, self-sustaining, and desirable revegetation occurs wherever practicable on lands disturbed by RBOSP mining operations in accordance with the lease stipulations. This monitoring program will provide the necessary data to determine if the criteria of revegetation success have been successfully met.

B. Methods - The following monitoring program is based on revegetation methodology currently available and the RBOSP revegetation experimental program. As more data becomes available, revisions in the proposed monitoring program may be necessary.

Areas disturbed along roads, around buildings, and within corridors will be monitored qualitatively. Revegetation efforts in these areas will be considered successful when a self-sustaining vegetative cover is established which is comparable in percent cover and species composition to the surrounding vegetation.

Emphasis of the monitoring program will be directed toward revegetated processed shale and overburden disposal piles since these areas present more potential problems for successful rehabilitation. During Phase I, approximately 35 acres per year will be revegetated as compared to 50 to 100 acres per year in Phase II (See Section 9, Chapter 8.4). Each unit of revegetated land will be monitored according to the following plan.

If warranted, annual composite vegetative cover maps of the disposal piles will be produced subsequent to artificial seeding of each area. These maps will provide a measure of the revegetation progress as areas become available for revegetation and an indication of the successional status of each revegetated area.

Following seeding of each revegetation unit, an intensive quantitative sampling program will be initiated which will encompass the first three growing seasons following seeding. This program will be similar to the current revegetation experimental program since the current program will provide a basis for comparison.

In each revegetated unit, 100 quadrats (1 m x .5 m or 3 ft x 1.5 ft) will be sampled along randomly located transects. Ten quadrats located at 10 m (33 ft) intervals will be sampled along each transect. Percent cover and species composition will be measured at the end of each growing season for three consecutive years. During the third year, above ground biomass will be measured by the harvest method in one-half of the established quadrats. During this period, qualitative assessments of sulfur dioxide damage, plant vigor, and other vegetative conditions will be made.

If plant establishment has been satisfactory during this initial 3 year period, monitoring will then be reduced to remove sensing surveillance beginning in the 5th year and continuing at 5 year intervals. Remote sensing surveillance will provide an estimate of percent cover, vegetation distribution, and erosion damage necessary to determine the self-sustaining capacity of the established plant community. Aerial photography will also provide documentation of vegetation successional patterns on the disposal piles.

As part of the revegetation monitoring, a soils program will be initiated to monitor salinity and heavy metals concentrations in the artificial soil profile of the disposal piles. Data from this program will indicate the long term success of the artificial soil profile to inhibit salt migration into the plant growth medium and will determine if heavy metals deposition has occurred as a result of emission blowdown from the processing plant. A soils program will be initiated for the initial areas revegetated on both the processed shale and overburden disposal piles. One soil sample per 2 ha (5 acres) will be collected at depths of 0 - 10 cm and 30 - 40 cm in the artificial soil profile. Samples collected from the overburden disposal pile will serve as "controls" for naturally occurring salinity in the area. Parameters to be analyzed include pH, conductivity, chloride, sodium, calcium and several heavy metals such as arsenic, zinc, cadmium, molybdenum and selenium. Samples will be collected once at the end of the growing season during years 1, 2, 3 and 5 and thereafter at 5 year intervals. If data from these two sampled areas indicate that salt migration into the artificial soil profile and accumulation of heavy metals do not occur, then no new sampling areas will be initiated for soil sampling. The two initial sampling areas will continue to be monitored at 5 year intervals until it can be safely assumed that the adverse effects of processed shale on revegetation efforts are eliminated by the artificial soil profile.

Form 1279—3
(June 1984)

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